TRANSACTIONS

OF

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS

VOL. 1.

FIRST ANNUAL MEETING

NEW YORK, JANUARY 22-24,

1895.

PUBLISHED BY THE SOCIETY,

AT THE OFFICE OF THE SECRETARY,

NEW YORK CITY.

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PREFACE.

The American Society of Heating and Ventilating Engineers was first talked of, at least with the idea of at once forming such society, during a visit of the present secretary of the society to the office of Hugh J. Barron, New York city, in the summer of 1894. This was just after the annual meeting of the Master Steam and Hot Water Fitters' Association, and while recognizing the great value of that association as a trade organization, it was thought that the time was ripe for a purely engineering society, composed of the active workers in the field of heating and ventilating work, at whose meetings subjects most interesting to the engineer would be discussed. As the result of this interchange of ideas the present secretary took it upon himself to ask the opinions of fifty or seventy-five engineers known to be much interested in their chosen line of work, as to the advisability of forming such an organization.

So many favorable replies were received that invitations were sent out to about twenty-five persons in New York city to come together at the office of Heating and Ventilation, 146 World Building, New York, Thursday, August 2nd, 1894. The following persons responded personally: A. A. Cary, James A. Harding, George B. Cobb, Hugh J. Barron, H. M. Swetland, W. M. Mackay, W. A. Russell, W. B. Wilkinson, Thomas Barwick, F. P. Smith, Albert A. Cryer, Edward A. Monroe, Percival H. Seward, O. C. Breckenridge, and L. H. Hart. Mr. Fred. P. Smith was elected temporary chairman and L. H. Hart temporary clerk.

After discussion as to best methods of forming the society, etc., H. J. Barron moved that a committee of five on organization be selected and that a committee of three be appointed to select such a committee.

The committee on organization selected were Messrs. Fred. P. Smith, H. J. Barron, James A. Harding, W. M. Mackay, and A. A. Cary. The committee on organization were authorized to issue invitations and select the place of the next meeting. Motion was made by Mr. Cary, and carried, that those present sign a paper agreeing to form an organization of heating and ventilating engineers, and that they be made charter members.

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The meeting was then adjourned to Sept. 10th, at the call of the committee.

The committee on organization set actively at work correcting a list of persons who were to be invited to become charter members, and circulars explaining the necessary qualifications were sent out with the invitations. In the meantime the committee worked hard and faithfully, formulating a constitution and by-laws for presentation at the next meeting.

The first regular meeting was called to order at 3 P. M., Sept. 10th, 1894, at the Broadway Central Hotel, New York, Mr. F. P. Smith in the chair, L. H. Hart, clerk. Mr. Smith explained the objects, advantages, and policy of the proposed organization.

Roll call found that 75 persons had become charter members. The present constitution and by-laws were adopted after some discussion and amendments to the one presented by the committee on organization. It was voted that the name of the society should be The American Society of Heating and Ventilating Engineers.

The constitution provides for an annual meeting in New York in January of each year, provision also being made for a semi-annual meeting to be held at various cities, date and place to be fixed at the annual meeting.

The following officers were elected to hold office until the first annual meeting in January, 1895: President, E. P. Bates, Syracuse, N. Y.; first vice-president, W. M. Mackay, New York; second vice-president, W. F. Wolfe, Boston, Mass.; third vice-president, Chas. S. Onderdonk, Philadelphia, Pa.; treasurer, Judson A. Goodrich, New York; secretary, L. H. Hart, 146 World Building, New York; board of managers, F. P. Smith, H. J. Barron, A. A. Cary, New York; James A. Harding, Vineyard Haven, Mass.; Henry Adams, Washington D. C.; council on membership: Chas. W. Newton, Baltimore, Md.; R. C. Carpenter, Ithaca, N. Y.; Albert A. Cryer, New York, F. W. Foster, Boston, U. G. Hallay, Brooklyn, N. Y.

L. H. HART, Secretary.

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PROCEEDINGS

OF THE

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

FIRST ANNUAL MEETING.

New York City, Jan. 22, 23, and 24, 1895.

OPENING SESSION, TUESDAY MORNING, JAN. 22.

The first annual meeting of The American Society of Heating and Ventilating Engineers was held at No. 12 West 31st street, New York city, January 22nd, 23rd, and 24th, 1895, the meeting being called to order at 10:50 A. M. on January 22nd by the president of the society, Mr. Edward P. Bates, of Syracuse, N. Y.

The secretary called the roll. The following members were present then or at some time during the meeting:

Adams, Henry, Washington, D. C.
Andrus, Newell P., Brooklyn.
Barron, Hugh J., New York.
Barwick, Thomas, New York.
Bates, Edw. P., Syracuse, N. Y.
Blackmore, J. J., New York.
Burns, Samuel, New York
Carpenter, B. Harold, Wilkesbarre, Pa.
Cary, Albert A., New York.
Cobb, Geo. B., New York.
Cryer, Albert A., New York.
Cryer, T. B., Newark, N. J.
Dewey, W. H., New York,
Edgar, A. C., Philadelphia.
Fish, John A., Boston.
Foster, F. W., Boston.
Goodrich, J. A., New York
Harding, James A., Boston.
Hart, L. H., New York.
Hauss, Chas. F., New York.
Hill, Wm. H., New York.
Hopkins, Chas. S, Rochester, N. Y.
Hunting, Alfred A., Boston.
Jellett, Stewart A., Philadelphia.
Light, Maj. H. E., Saginaw, Mich.
Lincoln, Chas. C., New York.
Longenecker, C. K., New York.
Mackay, W. M., New York,
McMannis, Wm., New York.
Munro, Edw. A, Brooklyn.
Munroe, Robt., Pittsburg, Pa.
Onderdonk, Chas. S., Philadelphia.
Paul, A. G., Boston.
Quay, D. M., Chicago.
Russell, Wm. A., New York.
Scollay, N. G., Brooklyn.
Seward, P. H., New York.
Sherman, Leroy B., New York.
Smith, F. P., New York.
Stangland, B. F., New York.
Stoughton, Jos M., Yonkers, N. Y.
Tompkins, S. D., Jersey City.
Wilkinson, W. B., New York.
Wilson, J. J., Troy, N. Y.
Weymouth, G H., Brooklyn.

The President:—Next in order is the reading of the minutes of of the previous meeting.

On motion of Mr. W. M. Mackay, the reading of the minutes of the previous meeting was dispensed with.

President Bates delivered his annual address.

The Secretary :—With the permission of the president, I will announce that the following candidates have been elected to the different memberships in the society : William Harry Dewey, 94 Centre street, New York, member ; Samuel D. Tompkins, Jersey City, N. J., associate ; George H. Weymouth, 331 Washington avenue, Scranton, Pa., junior ; Thomas Thomson, Coal Exchange, Scranton, Pa., associate ; Norman S. Kellogg 43 Milk street, Boston, Mass., member ; Andrew G. Paul, 10-12 Federal street, Boston, Mass., associate.

The secretary presented the following report :

REPORT OF SECRETARY.

The society has, at the present time, 75 members. A few more have been voted on, and the successful candidates will be announced by the council at this meeting. We have also eight more candidates that have been accepted by the council whose names will be sent to each member to vote on soon after the meeting. In addition to this there are several other applications in the hands of the council. I believe there is a general feeling throughout the country that the future of this society will be a glorious one ; its success is already assured.

There is a large expense attached to printing the papers and making cuts for them, but I have done all I could to reduce the cost. The board of managers have met frequently, and much work that it is impossible to show in a report has been accomplished. I thank them and also the council for the help they have given me in advancing the interests of the society.

REPORT OF TREASURER.

In the absence of Treasurer J. A. Goodrich his report was read by Mr. Hart, as follows :

Cash received (membership assessment).....	$750.00
Cash paid, as per order of Board of Managers....	256.82
Balance in hand in Washington Trust Co....	$493.18

Letters expressing the writers' regret at their inability to be present were read from Messrs. John Gormley, Henry B. Prather, J. H. Kinealy, James Mackay, Charles W. Light, Thomas Thomson, H. D. Crane, James R. Willett, George D. Hoffman, and John H. Petherick.

The President :—The next in order is the report of the chair-

man of the board of managers. I understand that the chairman is not here in person, but he is represented, I believe, by Mr. Mackay, and Mr. Mackay will kindly make such a report as he can under the circumstances.

Mr. W. M. Mackay :—Mr. President and Fellow Members : I did not come prepared to say anything, supposing that Mr. Smith, our chairman, would be here. The members of the board of managers, since the organization of the society, have had weekly meetings. They have considered the objects set forth in the constitution as to the intention and aims of the society, and have endeavored to follow them so far as possible. They have organized a committee for the purpose of considering the interests of legislation in connection with the heating and ventilation of buildings. They have done a good deal of work in regard to this first annual meeting, and the different members have certainly done all that it was possible for them to do without neglecting their own business. I feel that this is really about all that can be said at the present time in regard to what they have done. I shall be glad to answer any questions which may be asked by any of the members.

The President :—The report of the chairman of the council is next in order. Is there anyone here who represents the chairman of the council ? (No response).

The appointment of the nominating committee is next. As I understand the appointment is made by the Chair.

The Secretary :—That is as I understand it.

The President :—In order that there may be no delay in the matter, I appoint the following committee on nominations : H. J. Barron, J. A. Harding, F. W. Foster, Albert A. Cryer, and Henry Adams, and I request this committee to report to-morrow at the opening of our morning session.

The reports of special committees come next. What special committees are there to report, Mr. Secretary ?

The Secretary :—There is no special committee to report this morning, Mr. President.

The President:—The next order of business is the reading of papers. Unless there is some special business that precedes that, we will proceed to the reading and discussion of papers. The first paper on the programme is, "Determining the Heating Power of Heating Systems," by Prof. J. H. Kinealy.

The paper was then read by the secretary, and after being discussed by Mr. J. J. Blackmore, the president asked, "Is there any further discussion on this paper?"

Mr. H. J. Barron:—I move that the further discussion of this paper be deferred until such time as the council may determine. It is not my object to have this paper put to one side without full discussion, but in order that the paper may be fully discussed at a future time, I move you, sir, that the further discussion of it be deferred until such time as the council shall determine.

Mr. Blackmore:—There is no reason why that motion should not be seconded. But time is rapidly slipping away, and the opportunities for making this test will soon be over for this season. It is important, even though the society defer action as a society, that every member should, so far as possible, make tests of plants in this vicinity, so that we can determine this problem. I appreciate the fact that it is one of the most important things that has been brought before the heating fraternity; that we should have some standard by which to determine the power of a heating apparatus. If we could adopt some standard, such as is here pointed towards, by which we could put in our specifications that a building shall be heated in zero weather or its equivalent, as determined by whatever work we shall decide to accept, it is a very important thing, and it is a thing the proper investigation of which we cannot afford to defer longer than is necessary. I would second the motion, except for that. But I would like to hear a little further expression from the members.

The President:—If Mr. Barron will allow me, I would suggest that in case this paper is passed, that does not consign it to oblivion. It can be recalled at any future meeting of the society and discussed further, and if the gentlemen here are prepared to discuss it, I see no reason why we should put off the discussion.

Mr. Barron:—With the consent of the seconder, I withdraw my motion. My idea was simply to suggest to the council to fix a time for the discussion of the paper. We may fail to have very much discussion just now, and we may take it up this afternoon or to-morrow.

Mr. J. J. Wilson:—I suppose Mr. Barron's idea is to give the members an opportunity to look over the paper. A great many, I believe, did not receive the papers before last Wednesday. I think his point is well taken—to give us a chance to look it over a little more thoroughly and possibly make the discussion a little more interesting on that account.

The President:—Well, if there is no further discussion, we shall pass on to the second paper.

Secretary Hart:—Do I understand that it is held over?

The President:—Every paper is held over in the sense that we

can go back to our papers and take them up at any future meeting, and discuss them if it is desirable. The paper is not put away because the discussion has ceased.

Mr. John A. Fish:—I would like to have that paper discussed, if it may be called up at a future time.

The President:—Certainly, we can call up a paper at any time, if it is the wish of the members.

The gentlemen who have presented the two following papers haven't come in yet, and it is suggested that we read the fourth paper, "A Short Talk on Hot Water Radiators," by J. J. Wilson. Mr. Wilson is present and will give a synopsis of his article.

Mr. Wilson then read his paper,—following the discussion of which by Messrs. Fish, Harding, Mackay, Seward, and Barron, the president said:

"It is suggested that we now take a recess. I think Mr. Wilson may be flattered to think that his paper has been pretty well pulled to pieces. If we are going to bring in papers we should go to work and pick them to pieces. We need not let anything go by default. Let us have a good, free, open discussion on the papers. We will take a recess until 2:30. Before we leave the room, however, there is a communication which came in which may be of importance."

Secretary Hart read the following letter from Mr. Rufus R. Wade, chief of the Massachusetts District Police.

Your very cordial invitation to be present at the first annual meeting of The American Society of Heating and Ventilating Engineers is received.

It would have afforded me great pleasure to have attended the meeting, but I regret to say that, owing to sickness in my family, I am prevented from attending and from hearing much that will be said on subjects in which I feel the deepest interest. You will pardon me if I improve this opportunity to add a few thoughts which, from many years of practical experience in matters relating to heating and ventilating occupied apartments, suggest themselves to my mind.

The practical experience and exceptional opportunities that have been afforded me during the past six years in matters pertaining to the heating and ventilating of school buildings have demonstrated this fact; that the failures that have so frequently occurred in methods or systems intended to secure good ventilation have been due to the fact that theory has been applied too closely to details.

It is well known to you that ventilation rests on certain general principles, and must conform to well-known laws of motion and

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matter, and it is also known to you that in the construction of the means to secure good results, the mechanical knowledge of the theoretical principles involved becomes a most important factor.

The failure to observe and carry out this mechanical knowledge of ventilation has, in my judgment, been the primary cause of the repeated failures in not securing the results desired by the system or method applied.

In the early history of the enforcement of the laws relating to ventilation in this state, it was fixed by this department that the minimum amount of air supply for each pupil in our school rooms should be 30 cubic feet per minute. At the present time I find, by the reports of the inspectors who are assigned to the special duty of ventilating work, that the average supply of fresh warm air in school-rooms in which the improved system has been applied is 45 cubic feet of pure fresh air per minute to each pupil, to each pupil, and the reports are by no means exceptional. This statement can be relied upon as an accurate average.

Your organization will be, and it cannot help being, of great importance. Its influence will be felt, not only locally, but will suggest and secure legislation which is so much needed in the matter of proper ventilation of schools and other public buildings, and which is of such vital importance to the human race.

I wish you unbounded success as an organization. I trust that at some future time I may have the honor of meeting with you, to hear and learn much that will be to me of great practical benefit.

AFTERNOON SESSION.

The meeting was called to order at 2:50 P. M.

Secretary Hart read the following telegrams :

CHICAGO, Ill., January 21, 1895.

L. H. HART, Secretary American Society Heating and Ventilating Engineers, New York City:
Regret my inabil ty to be present. Best wishes for success.

T. J. WATERS.

BUFFALO, N. Y., January, 22, 1895

L. H. HART, Secretary:
Cannot be with you to-morrow. Please read my paper. I mail discussion on Topic 10 by quick delivery. Wish you great success.

HENRY PRATHER.

The President :—Do the gentlemen wish to make any remarks on the first paper ? Do you think you could add anything further to your paper, Mr. Wilson ?

Mr. Barron : I move that Mr. Wilson be allowed to sum up. It is perhaps only fair that Mr. Wilson should have that opportunity.

The President :—We will hold the watch on you for three minutes, Mr. Wilson.

Mr. Wilson then made a few additional remarks.

The President :—It is suggested now that we take up these topics for discussion. I think that the Chair will take the liberty of calling down any gentleman who stays too long on the floor, so that all may have an opportunity. It will be greatly to our advantage to say what we have to say concisely and briefly and let your neighbor have an opportunity. Prof. Carpenter has not come in yet, and as he is not here we will take up this first topic for discussion. Please confine yourselves to a short, brief, terse discussion and try not to repeat. If there is any pertinent point we will give you a second chance.

The discussion of the first topic was then taken up.

The President :—I do not know but that it would be wise while we are all here together to set our hours of meeting for to-morrow. What is the pleasure of the gentlemen as to our meeting to-morrow morning? We must evidently have a meeting to-morrow, as we shall not get through with our work to-day. What hour shall we meet in the morning? The nominating committee is to report at the opening session.

Mr. Barron :—I move that the hours be the same as they were to-day, ten o'clock for the morning session and 2:30 for the afternoon session.

Mr. Onderdonk :—Has it been the intention to have an evening session at all? I was wondering if we could get a larger attendance of members in business in New York if we had an evening session.

Mr.. Barron :—After the first motion was carried I intended to bring that up as a separate matter.

Mr. Fish :—I would second his motion.

Secretary Hart :—Mr. McMannis, the chief engineer of the city schools, is here with us to-day and he has kindly invited any of the members here to visit some of the schools, or he will take members to his office to examine the plans and specifications of some of the large new schools they are going to build here.

The President :—If it is the wish of any large party of the members to inspect these schools or the plans it might be convenient to do so. If you wish to come here for the business of the association entirely and to spend all your time here that is another matter.

The motion is before you to have the meetings at ten o'clock in the morning and 2:30 in the afternoon. (Motion carried.)

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The President :—Mr. Jellett, will you present your paper now ?

Mr. Jellett :—I was asked some time ago to prepare a paper for these proceedings. I did not then think that I would have time to prepare such a paper, but about Christmas I found that I had a little leisure. It was then too late, but I have written a sketch with the idea of opening a discussion. I simply present it, therefore, with the idea of having it freely discussed, and I hope that all the members present will discuss it freely from every point, because I think it affects us all whether we are consulting engineers only, or contractors and consulting engineers.

Mr. Jellet then read his paper entitled, "The Heating and Ventilating Engineer—A Commercial View."

At the close of the discussion on this paper the following motion was presented.

Major Light :—I move that a committee be appointed to draft a resolution covering this question under debate and present it at the afternoon session to-morrow.

The President :—I do not think I can entertain the motion at the present time. We are now discussing papers and shall continue under that heading.

Mr. Jellett :—In article I, section 4, sub-division 8, of our constitution, it is stated that among the objects of our society is the establishment of a uniform scale of prices for all professional services. All—it does not omit any. It is for the board of managers to formulate such a plan. I should look, as a member, to them to suggest a scale of prices, and when the board of managers recommend such a scale I should expect to follow that scale and ask those prices.

The President :—The secretary will read the next topic.

Secretary Hart :—The second topic for discussion is now before you. It is : In a plenum system of heating and ventilation, which is the better for the air ducts, "off and on" hot and tempered air dampers or "mixer" dampers?

Discussion on this topic was followed by the reading of the third topic, but on motion of Mr. Blackmore, who explained that the question came very much in line with Prof. Carpenter's paper to be read later, the discussion of the third topic was deferred and the fourth topic taken up. This was : The necessary size of risers for a given amount of heating surface for the different sizes of pipes and coils and for different classes of radiators.

After discussing the fourth topic, the president announced that, at the request of some of the members, the sixth topic, "the probable future of electrical heating," would be discussed, calling

upon Mr. Jellett, who presented the topic, to open the discussion.

Adjournment to Wednesday morning followed the discussion of the sixth topic.

MORNING SESSION. SECOND DAY.

The meeting was called to order at 10:35 A. M., on Wednesday, January 23rd, by President Bates.

The President :—I wish at the opening of this session to make a little correction. I will ask our stenographer to take this. In our deliberations yesterday there was a little tendency to belittle the architects. Gentlemen, this is wrong. You would not be here if it was not for the architects. There would be no use for you. I can take you down to the North River and put you on board a steamer and in a week I can land you in a country where there are no architects, and where there are no heating or ventilating engineers either. Now we do not make the architect. The architect made us. When a man gets to a point where he says I was a man before my mother, he is treading on uncertain ground. Let us treat the architects with all the respect that is due to them and their profession. We are largely dependent on them for our business, those of us who are in business. Those of us who make a specialty of heating and ventilation from the professional standpoint only are largely indebted to the architects. We might as well look at this thing from a rational standpoint. You take the best architects in the country—they do not tell you that they know everything. As I understand it they take the position of the general of an army. An owner goes to them and says, "I wish to construct a certain device ; I wish to occupy so much ground and invest a certain amount of money. In order to do this I must employ 10, 20, or 50 different trades to construct this device." But all of this goes through the hands of the architect, and that is right. If he is a broad-gauged man of experience, he will come to one of our profession and employ him to look after the heating and ventilation of the building. He goes to the best plumber he knows of and gets a system of plumbing. He goes to an experienced roof man and gets his idea of roofing, and so on through the different trades. He combines that information and gives it to the owner, and he puts up a magnificent structure that we are all proud of. We are all proud that we had something to do with that structure. It is a credit to every mechanic who worked on it. It is a credit to the achitect. It is a credit to the city in which it is built. It is a credit to the

whole world. Let us in our future deliberations, if we speak of architects, let us speak of them in such a way as their profession demands, with the greatest respect and condescension, and I will ask the newspaper men here present and our own stenographer, with your permission, to eliminate from their notes anything that has been said here that would tend in any way to belittle the profession of architecture. I will ask you further in your deliberations to make good choice of your language. We are not here as tradespeople. We are not here to force goods on the market, or cry down any other person's goods—nothing of the kind. We are here to talk about theories. We are here to tell of practical results which we may have obtained in experience. You are not here to speak of anybody else in a way that will belittle him or his goods or his practice. Now let us keep on this plane of thought, and it will be an improvement for us all. We are just starting now. Let us start right and hold to the right, and our deliberations here, and our papers, and all that we do, will have a good effect, not only on us, but on the people whom we design to reach.

We have some communications which perhaps had better be presented at this time, if the secretary would read them.

Secretary Hart then read letters of regret from R. C. Carpenter, John Demarest, and W. F. Wolfe.

The President :—Is the nominating committee ready to report ?

Mr. Harding :—Yes, sir.

The President :—They will please make their report.

Mr. Harding :—The nominating committee have prepared the nominations for all but the council and the board of managers. Those nominations will be finished immediately after the election of the other officers. I will explain that two candidates are required for each office. The nominations are as follows :

President, Edward P. Bates, Charles W. Newton ; first vice-president, W. M. Mackay, Fred. P. Smith ; second vice-president, Charles S. Onderdonk, H. D. Crane ; third vice-president, Stewart A. Jellett, T. J. Waters ; secretary, L. H. Hart, Edward A. Munro ; treasurer, J. A. Goodrich, George B. Cobb.

Mr. Jellett :—If it is in order I would like to withdraw my name as a candidate for office. I do not care to stand for it at all. I am very much interested in matters in connection with the society. I will be just as much interested in the rank and file as if I were an officer. I have more to do as a rule than I well can attend to. I think there are some men here older and more experienced whom it would be more fitting to place in that position. I should consider it a favor if that request be considered.

The President :—What is the pleasure of the meeting as regards these nominations ?

Mr. Barron :—I suppose it is in order to make a motion that the nominations now close.

The President :—I think so.

Mr. Barron :—Before making that motion I wish to ask Mr. Jellett to withdraw his declination. We cannot afford not to have Mr. Jellet around. In fact we do not consider it in the best taste for any one here to withdraw after being nominated. The nominating committee worked hard to select what they thought the most available men, and as there must be two candidates for every office, they feel that those nominated should stand; whether they ought to be elected or not is another question. I move now that the nominations close. (The motion was carried.)

Mr. Barron :—I move now, Mr. President, if it is in order, that the election be taken up at 12:30 sharp or any hour that would be convenient. But I think we ought to fix on an hour for the election.

The President :—If I am rightly informed I think it is important that the election take place early for this reason, that the board of managers, if I understand right, become the board of trustees, and in order to incorporate the society a certain amount of work must be done in one day, and it would be well to do that while we are all here present, so in that view it would be well to have your election early. What do you think, Mr. Harding?

Mr. Harding :—The articles of incorporation will have to be signed by the board of managers as trustees for the association on the day that they are elected, provided they are elected for one year, as they must remain trustees for one year. I have advised the attorney employed by the board for the society to be here at 2:30 to-day. If the election of the officers whose names I have read can be accomplished, say, by 12 o'clock, or the election can be started at 12 o'clock, we should be able to make up the nominations for the board of managers and council immediately after, and probably finish the election within an hour, or by 1 o'clock, and by that means we shall have everything read for the attorney when he comes, and we will be able to file the articles to-day, which is important.

The President :—It is moved and seconded that we take up the election of officers as a matter of business at 12 o'clock to-day.

The motion was carried.

The President :—I think it would be perhaps a proper time to present a communication which refers to Mr. Jellett's paper.

A communication from Prof. R. C. Carpenter, containing the remarks which are attributed to this gentleman in the discussion fol-

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lowing Mr. Jellett's paper was then read by the secretary.

The President :—There is one matter before us, gentlemen, which I do not think we have disposed of. We received an invitation from one of the city officials yesterday, and it seems to me that we should dispose of that invitation in some way. If you gentlemen care to take some time to-morrow to visit the schools here or to examine those plans which have been prepared for the heating and ventilation of schools, it may be interesting for you to do so. If you wish to do so in a body, the time could be arranged. If you wish to do so individually, that is your privilege. What is your pleasure in regard to this invitation ?

Mr. Barron :—Mr. President, the idea was not, perhaps, for the whole society to be there, but for a little party to be made up of those interested in school heating. Any who would like to go and examine the plans for heating New York schools can leave their names with the secretary.

Secretary Hart :—Mr. McMannis will be here by-and-by, I think, and then perhaps the members can talk with him on the matter.

The President :—We have a paper by Mr. Hunting which we will now listen to.

Mr. Alfred A. Hunting then read his paper on "Heating and Drying by the Use of Exhaust Steam and Live Steam Reduced to Low Pressure, Either Separately or in Combination."

Following the discussion of the last named paper by Mr. Onderdonk, the president said, "If there is nothing further we will pass to the next paper. Mr. Harding, will you read Prof. Carpenter's paper or give a synopsis of it ?"

The paper by Prof. R. C. Carpenter on "Testing of Steam Radiators" was then read by Mr. Harding.

After some discussion on this paper by Messrs. Barron, Harding, Jellett, and Blackmore, the president said: The time has come, gentlemen, which you set for the election of officers. Mr. Quay and Mr. Paul will please act as tellers.

There seems to be a little misunderstanding here about the candidates for the first office. In order that there should not be any misunderstanding, when I entered this room yesterday morning I stated my position very plainly, thanking the nominating committee for all courtesies and everything of that kind, and I said that circumstances existed which would make it impossible for me to be a candidate here for the position which I have only held practically for two days, although nominally for a few months. I will ask you to cast all your ballots for the other candidate at my request. It will make no confusion and it will make it unnecessary for me to

say anything after the ballots are cast. I thank you for your courtesy and your kind feeling very much.

The society then proceeded to ballot for President.

The President :—The nominating committee will please read the names of the candidates for the next office.

Mr. Harding :—The candidates for the office of first vice-president are W. M. Mackay and Fred. P. Smith ; for second vice-president, Charles S. Onderdonk and H. D. Crane ; for third vice-president, Stewart A. Jellett and T. J. Waters.

The President :—Please prepare your ballots for vice-presidents, writing the names for the first at the top, the second next, and the third last. Please prepare your ballots while the tellers are counting the ballots for president.

Mr. Quay announced the result of the ballot for president to be as follows: whole number of votes cast, *22*; for Mr. Bates, 16; for Mr. Newton, 7.

The President :—Gentlemen, I thank you for the compliment, but I will have to adhere to what I said. For reasons which I cannot state to you in open meeting, I came to a decision in this matter, thinking you might wish to compliment me, and I told the managers I could not accept the nomination. I told them in advance so that they might prepare such names as they chose, and I was surprised when they brought in my name this morning as a possible candidate. I think you will have to ballot again or make some arrangement to get a president, as I cannot take the position for another year.

A Member :—I move that in view of the circumstances the tellers be instructed to cast one ballot for Mr. Newton.

The President :—Gentlemen, I will put that a little differently. You can ask unanimous consent of this meeting that a certain person may cast a ballot that way, and if no one objects it can be done. I hear no objection ; the teller can cast the ballot.

Mr. Barron :—I object to that, decidedly. I got up to object when the gentleman made the motion. I think it is entirely out of order. You have elected a candidate and I do not see how you can go back on that election. I do not see how it is possible for the president to decline. By allowing us to vote, I think you have done it. It will interfere with our constitution, I think.

The President :—Where it is in order to proceed as we are proceeding now, it is in order for a teller to cast a vote. You do not seriously object ?

Mr. Barron :—I do seriously object. I think we ought to insist on your retaining the office for another year.

The President :—As I have repeatedly declined to be a candidate for good and sufficient reasons, I think I shall have to declare that there was not an election, and ask the gentlemen to prepare ballots for a candidate for president.

Mr. Hopkins :—It is in entire accord with parliamentary usage as I have experienced in a number of cases, for a motion to be made instructing the secretary to cast a vote for any individual. That becomes a motion and is voted on. If the asemblage votes instructing the secretary to do so, then it is passed of course ; otherwise it is defeated. If the assembly does not want to vote that way they can so decide.

The President :—My experience has been that where ballots are required unanimous consent must be given for someone to cast a ballot ; that we cannot vote to tell somebody else to cast it. I must so hold unless the house disagree with me.

Mr. Harding :—I would like to ask my friend Mr. Barron if he will not reconsider his objection. As the nominating committee we presented these names to the meeting, and if Mr. Bates positively declines, why we, as the nominating committee, are satisfied with the other candidate that we ourselves presented to the meeting, if the meeting itself does not object.

Mr. Barron:—According to the constitution, which strictly defines how a candidate is to be nominated and balloted for, this meeting cannot instruct a man to deposit that ballot. I have a ballot according to the constitution, and I think the presiding officer would have to so rule, that we have got to present two candidates for the meeting and they have got to be elected by ballot, and as long as one man objects to any other mode of election I think the constitutional mode of election would have to be followed.

The President :—I should have to rule that unanimous consent must be given. If unanimous consent is given you can then proceed to deposit one ballot ; otherwise you cannot. As there is an objection, I ask the gentlemen to proceed to prepare ballots.

Mr. Quay :—Wouldn't it be the proper thing for the nominating committee to nominate another candidate ? If there is only one nomination of course we know who will be elected.

The President :—I think your point is well taken, Mr. Quay, and I think it would be well for the nominating committee to present two candidates.

After a brief conference the nominating committee, through Mr. Harding, presented the names of Charles W. Newton and L. H. Prentice as candidates for president.

The President :—Gentlemen, you will please prepare your ballots.

The tellers reported that the balloting for president had resulted as follows: Whole number of votes cast, 24; for Mr. Newton, 20; for Mr. Prentice, 4.

The Chairman :—Gentlemen, does any of you who voted for Mr. Prentice wish to make a motion that the election of Mr. Newton be made unanimous ?

Mr. Barron :—I make that motion, Mr. Chairman, that the election of Mr. Newton be made unanimous.

The motion was carried.

The Chairman :—Mr. Newton is president for the coming year. You will please deposit your ballots for vice-presidents. The nominating committee will please read the names of the candidates for secretary.

Mr. Harding :—The nominations for secretary are L. H. Hart and Edward A. Munro, and for treasurer Judson A. Goodrich and George B. Cobb.

The Chairman :—I think it will expedite matters to vote for both on the same ticket, putting the person voted for for secretary on the top of the ballot and the treasurer underneath.

While the balloting for vice-presidents proceeded, the chairman said :

I was saying to our secretary a few minutes ago that the Mechanical Engineers, who own this building, have a very good system of electing their officers, and I would suggest that in another year we look into the matter, and, if possible, adopt their system. The nominations are made by a committee yearly, and those nominations are printed and sent to the members by mail. You vote on them and return them. The vote is counted and the announcement of the result is made at the annual meeting. It saves time. It has worked very nicely in that society. I am free to say right here that we can well afford to pattern after the conduct of that society in every detail, so far as I am acquainted with it. I have been a member of it a few years, and I have never been a member of any society or institution where the business was conducted so nicely and quietly, or methodically, so mechanically, as it were, as in that society. I would suggest to the members that you look into their methods, and if they are agreeable to you, it may be very well to adopt them as your rule, because they have been carefully considered and are the result of a good deal of experience and study, and everything is done in that society, so far as I am advised, to save the time of the members. I think we have done pretty well in our papers in our discussions. We can improve in another meeting very much. You can probably pre-

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pare your papers a little earlier and have them printed and send them out to the members, and it will be a good idea, if you intend to discuss a paper, to send your name in in advance and be prepared to discuss certain papers. You will then bring your remarks down in a very concise form and say just what you wish to say without repetition, and without taking the time of the association, and we can do that without taking so much time as we have been obliged to take here. This is our first meeting, and at future meetings no doubt we will get better discussions, clearer discussion and more to the point. I think we have done very nicely for a new society, but our methods can all be improved, if we will each apply ourselves to them somewhat.

Mr. Jellett :—In order to carry that out it would be necessary to present an amendment in writing to be acted on at the next meeting, as it effects the constitution. I would propose such an amendment, and I will write it out and present it.

The Chairman :—If you will present such an amendment we will lay it before the house for discussion and adoption, if you please.

The tellers will please announce the result of the balloting for vice-presidents.

Mr. Quay :—For first vice-president, Mr. Mackay received 18 votes and Mr. Smith 5 ; for second vice-president, Mr. Onderdonk received 20 votes and Mr. Crane 3 ; for third vice-president, Mr. Jellett 16, Mr. Waters 7.

The Chairman :—Do you wish to make the election of Mr. Mackay unanimous as first vice-president?

A member :—I move, Mr. Chairman, that the election be made unanimous.

The motion was carried. Similar motions were made and carried with respect to Mr. Onderdonk and Mr. Jellett.

The Chairman :—Please deposit your ballots for secretary and treasurer.

The balloting for secretary and treasurer then proceeded.

Mr. Jellett:—I would move to amend article VI of our constitution, on annual meetings and election of officers, so as to have the nominations made by the nominating committee printed and sent to members and votes returned before the annual meeting in the general manner now in use by the American Society of Mechanical Engineers. This is to be brought up at our next annual meeting.

The Chairman :—I will ask the secretary, whoever he may be, to convey this information to the members as to the method of procedure of the Mechanical Engineers, so that you may all under-

stand and know how to vote intelligently on the subject when you come together a year from now.

The tellers will announce the result of the vote for secretary and treasurer.

Mr. Quay :—Mr. Hart for secretary received 19 votes and Mr. Munro 3 ; for treasurer, Mr. Goodrich received 21 votes and Mr. Cobb 2.

The Chairman :—Mr. Hart is elected and Mr. Goodrich is elected.

Mr. Blackmore :—I move that we make the election of Mr. Hart unanimous.

The motion was carried. A similar motion with respect to Mr. Goodrich's election was made and carried.

The Chairman :—The nominating committee will report in a moment or two on candidates for council and managers. If there is any little matter of unfinished business we could take it up meanwhile.

Mr. Hopkins :—Is it in order that the first vice-president take the chair until the close of the meeting?

The Chairman :—It will be after we install our officers ; yes, sir.

Mr. Mackay :—I move that our present president retain the chair until the end of the meeting. (Seconded.)

The Chairman :—I do not think your motion is quite in order. I think that after our election is complete all the way through that our new officers should take their places. We have not completed our election yet. I think that is the proper course of procedure. I am sorry to say that I shall be obliged to be away this afternoon, and I shall have to call on my successor, or his nearest representative, to take the chair at the opening of this afternoon's session.

Mr. Quay :—I think as the motion has come from our first vice-president, that it would be in order to consider the motion.

The Chairman :—I can entertain the motion if it is the desire of the house. The only thing is I shall have to be absent at the opening of the session. I will return and work with you again as soon as possible. I think we might as well let it go in the usual way.

Mr. Quay :—I would like to hear the motion put, Mr. Chairman.

The Chairman :—The motion is that the former president retain the chair until the end of the session.

The motion was carried.

The nominating committee presented the following names of candidates for the board of managers, the names being placed on the blackboard : B. F. Stangland,* James A. Harding, George B. Cobb,* John A. Fish, William McMannis,* Wiltsie F. Wolf, C. C. Lincoln,* U. G. Scollay,* Thomas Barwick, Edward A. Munro.*

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The Chairman :—I have asked the secretary to place a star opposite the names of those candidates who live in this state, as at least three out of five must be residents of the state.

Mr. Harding :—The president and secretary are ex-officio members of the board of managers, and I might say that Mr. Hart is a resident of New York state and he would be one of a majority, and we require four out of seven, so that three of the candidates elected from that list should be residents of the state of New York and three may be residents elsewhere.

The following names of the candidates for council, presented by the nominating committee, were placed on the blackboard : R. C. Carpenter, A. A. Hunting, Henry Adams, H. D. Crane, Edward P. Bates, George B. Hoffman, A. A. Cryer, T. J. Waters, J. H. Kinealy, John D. Hibbard.

The Chairman :—The tellers will announce the result for the board of managers.

Mr. Paul :—The whole number of votes cast was 21. Mr. Hartley has 18, Mr. Stangland 16, Mr. Cobb 15, Mr. Scollay 12, Mr. Fish 11, Mr. McMannis 11, Mr. Lincoln 8, Mr. Wolfe 8, Mr. Munro 6, Mr. Barwick 3.

The Chairman (Mr. Mackay) :—There are four members elected, Mr. Harding, Mr. Stangland, Mr. Cobb, and Mr. Scollay. Members will prepare their ballots between Mr. Fish and Mr. McMannis.

This was done with the following result: Whole number of votes cast 20; Mr. McMannis 13, Mr. Fish 7.

The Chairman :—Mr. McMannis is duly elected. What is your pleasure with regard to those five names. Do you wish to make them unanimous?

Mr. Jellett :—I move that the election of those men be made unanimous.

The motion was carried.

The Chairman :—You will now prepare your ballots for the council. Five members are to be elected.

The balloting for members of the council resulted as follows : Mr. Carpenter received 20 votes, Mr. Bates 19, Mr. Henry Adams 13, Mr. T. J. Waters 13, Mr. Albert A. Cryer 9, Mr. Hunting 7, Mr. Hoffman 6.

The Chairman:—Prof. Carpenter, E. P. Bates, Henry Adams, and T. J. Waters are elected. What are you to do with the final nominations? All of the remaining names will have to go in on the second ballot. You have to elect one from Messrs. Cryer, Hunting, and Hoffman.

Mr. Harding :—I may be wrong, but it occurs to me that this

election is completed. It is the first five receiving the highest number of votes.

The Chairman :—Nine is not a majority of 20.

Mr. Harding :—It is impossible that there should be a majority, and it is not necessary.

The Chairman :—Then, gentlemen, Mr. Cryer having had the highest number, is elected a member of the council.

Mr. Barron :—I move that the election of these gentlemen be made unanimous.

The motion was carried and an adjournment was taken until 3 P. M.

AFTERNOON SESSION, SECOND DAY, JAN. 23.

The meeting was called to order at 3:15 P. M., Vice-President Mackay in the chair.

The Chairman :—We are under the head of discussion on Prof. Carpenter's paper.

Following the discussion of this paper by Messrs. Quay, Wilson, Jellett, Hopkins, and Onderdonk, the chairman asked, "Is there any further discussion on Prof. Carpenter's paper? If not we will pass to the paper on the 'Heating and Ventilation of School Buildings' by T. J. Waters, which will be read by the secretary."

The secretary then read Mr. Waters' paper.

The Chairman :—One or two of these former topics of discussion were passed over. Should any member wish to turn to them we will gladly do so, or we will now take up topic No. 7 : "Necessity of automatic air and water valves on steam systems."

Mr. Jellett :—Wouldn't it be desirable to finish these papers here before we take up topical discussions? The papers are really of much importance, and considerable pains was taken to have them before us at the proper time. The topical discussions are things which we can take up or drop as we please. But it is hardly fair to the men who take the trouble to write these papers to postpone reading them until many of the members have gone away.

The Chairman :—It has been suggested that we leave some of the papers over until to-morrow. At the same time, if it is the wish of the members that one or both of them be read this afternoon, we will certainly take them up. My sole object in taking up topical questions was to avoid crowding papers together too quickly. Still, if it is the wish of the members that any or all of these papers be taken up, we will gladly do so.

Mr. Wilson :—I make the motion, Mr. Chairman, that the papers be taken up in the regular order. (The motion was carried.)

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The Chairman :—Under that head we will take up the paper "A Prison Heating and Ventilating Plant," by H. B. Prather.

Mr. Prather's paper was then read by Mr. Stangland.

Following a few remarks on the subject of prison heating by Mr. Jellett, called forth by the reading of Mr. Prather's paper, the chairman called upon Mr. Barron to read his paper on "The Literature of Heating and Ventilating."

The Chairman :—We should be pleased to hear any discussion on Mr. Barron's paper. Does any member wish to discuss the paper further? It was brought up yesterday, and there was really no discussion on it. Considerable discussion on this paper then took place, and as a result the following suggestions were made.

Mr. Quay :—I undertsand that the Master Steam and Hot Water Fittters' Association have a committee to draw up a uniform specification. I should think if a committee were appointed by this association to confer with that committee it would answer the purpose better than if either association attended to it alone.

Mr. Harding :—I will make a motion that a committee of three or more be appointed for the purpose of conferring with the committee of the Master Steam and Hot Water Fitters in this matter of preparing an ideal specification for heating and ventilation.

Mr. Quay :—I would second that motion. I would like, with Mr. Harding's permission to add one thing to it—a uniform specification and contract. I think that is what the Master Steam Fitters are working on. It takes in the two.

Mr. Harding :—I accept that amendment.

The Chairman :—Who shall select the names, Mr. Harding?

Mr. Harding :—Perhaps the chair had better appoint a committee of three or five. I will put the motion in the form it has assumed—that the chair appoint a committee of three to confer with the committee of the National Steam and Hot Water Fitters' Association on the preparation of a uniform specification and contract for heating and ventilation of buildings.

Mr. Barron :—I am opposed to that motion. I think it is a little early. I think we should let the Master Steam and Hot Water Fitters attend to this matter, as long as they have undertaken it, without any advice from us. I do not regard it in the very best taste now to appoint a committee here to confer with them without their request. Besides, a number of our members are also members of that association. If they have it in charge they are perfectly competent to frame a contract. We are supposed to be simply engineers. We want to let the Master Steam and Hot Water Fitters' Association attend to these business matters. It

is their province and we ought not to interfere. For my part I do not want to recognize the Master Steam and Hot Water Fitters in any such way by acting in connection with them. If they offer such a specification I will approve it, but I will approve it as a steam fitter and not as a heating engineer. That is my opinion. I am opposed to doing anything just at present.

Mr. Smith :—I do not suppose that we are any bigger than the American Society of Architects, and yet when this uniform contract was drawn, the technical and the business end stood first. In this matter, if we are to draw specifications on which the contractor is to figure, why shouldn't we agree? We are not going to take away any of their dignity if we agree that we are going to agree with them. We are employed as engineers and we submit a contract to them under the form that this society approves of, and they bring in a contract under the form that they appprove of, and then the two bodies are acting inharmoniously. Now, why not confer?

Mr. Quay :—I heartily agree with the last speaker. I think a uniform contract coming from these two associations would have a better effect than from one alone. I think there would be a decided advantage in having this committee appointed and having it confer with the other committee.

The Chairman :—Mr. Harding, did you reduce the number to three?

Mr. Harding :—Three ; yes, sir.

The Chairman :—It has been moved by Mr. Harding, and seconded by Mr. Quay, that the chair appoint a committee of three to confer with the committee of the Master Steam and Hot Water Fitters' Association on the preparation of a suitable form of specification and contract for the heating and ventilation of buildings.

The motion was carried.

The Chairman :—I will appoint on that committee Mr. Jellett, Mr. Quay, and Mr. Smith.

Mr. Quay :—Won't you appoint some one in the East? I live out in the wooly West and a long distance from New York.

Mr. Smith :—I have been obliged to shirk so many of my duties as committeeman already that I feel very loath to take on myself the obligations of any further committee work. The board of managers would have to keep prodding me. My private business is very pressing. There are others who are members of both associations, and I think that a committee constituted of them would do better work than some one like myself who is not a member of the Steam Fitters' Association.

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The Chairman :—I think a good deal of the matter can be attended to by correspondence rather than by personal interview. I do not think that the committee of the Master Steam Fitters' Association will always be together. I do not think that the location has all to do with it. Mr. Smith being located in New York and the Steam Fitters being in New York, is a circumstance that will be helpful in the matter. Mr. Jellett is in easy touch with us. Mr. Quay can also give us the ideas of the wooly West, as he calls it.

Mr. Smith :—I am going to move that Mr. Barron be substituted for myself—

Mr. Barron :—I positively decline.

Mr. Smith:—Because he is just the man. He is a member of both associations.

Mr. Barron :—I am not a member of the Master Steam Fitters' Association, and I could not serve on such a committee.

Mr. Quay :—I withdraw my objection, Mr. Chairman.

The Chairman :—Then the committee will stand as appointed.

Major Light :—May I ask if there is to be a session to-morrow morning?

The Chairman :—I believe the intention is to continue until the business of the society is completed.

Mr. Harding :—There are several matters of routine business that have to be attended to. The by-laws say that in addition to the annual meeting there shall be a semi-annual meeting at places designated at the annual meeting. Some one said that Philadelphia would be a nice place for the semi-annual meeting in the summer season.

Mr. Quay :—I would like to have Chicago mentioned in connection with other places.

Mr. Jellett :—I understand that the American Society of Mechanical Engineers are going to meet here this evening, and it would be only proper to adjourn in time to allow them to get their room in order. If we can close up our business and adjourn until to-morrow morning we had better do it. The matter of a semi-annual meeting is a matter that will bear some discussion. I do not know whether or not it is a particularly desirable thing to do. I do not care to meet in July or August myself. I would rather get a vacation.

Mr. Barron :—I move that we adjourn.

Prof. F. R. Hutton :—Allusion has been made, Mr. Chairman, to the fact that you are going to hold a session to-morrow morning. Will you permit me, in the name of the American Society of Mechanical Engineers, to invite any of you to attend the monthly meet-

ing which is to be held this evening by the Society of Mechanical Engineers in this room, the occasion of the meeting being a talk by Mr. Alphonse Fteley, who is chief engineer of the water works of this city, giving an account of the growth and development of the system of water supply of New York. We should be very glad to see any members of your society at that meeting.

Mr. Harding :—I move that a vote of thanks be given to the Society of Mechanical Engineers for the invitation so kindly extended to the members of our society to be present at the meeting this evening.

The motion was carried and the meeting adjourned until the following day.

THIRD DAY'S PROCEEDINGS.

The meeting was called to order on Thursday, January 24th, at 10:50 A. M., Vice-President Mackay in the chair.

Mr. Barron :—In order to start the discussion this morning I would like very much to take Mr. Waters' paper and read a part of it and discuss part of it. There is not a very large attendance now and when there are more here we can take up other matters. Mr. Waters' paper did not receive any discussion whatever, and I hardly think it is fair to him to pass his paper without giving it some discussion.

The Chairman :—Do you wish to make a motion, Mr. Barron, that that paper be discussed?

Mr. Barron :—No, sir ; I ask your consent.

The Chairman :—I shall be very glad to give it.

Mr. Waters' paper was thereupon discussed by Mr. Barron and several other members, following which the announcement below was made.

Mr. Hart :—I wish to announce that Mr. Thomas E. McNeil, one of our old time heating engineers, is here. He is now a lecturer at the New York Trade Schools, between 67th and 68th streets and First avenue. If any of the members desire to go he will be glad to see them there at any time. To-morrow afternoon he is to deliver a lecture there before the trade school on steam fitting, etc. Mr. Baldwin is with us this morning and perhaps wishes to say something to the members about visiting the subways here should they desire to do so.

Mr. Baldwin :—The method of ventilation used in the subways of New York I designed and carried out and still have charge of. If any of the gentlemen here present wish to visit some of our blowing plants, I will take them there and have the manholes opened so

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that they may have an opportunity of seeing the results. We force air into the subways, into the manholes, so as to keep a pressure in the ground, arguing that air will move in the direction of least resistance. In the old subways that were laid before we began to use systematic ventilation, we simply carry air into the nearest manhole and it passes from manhole to manhole through the horizontal conduits. In that way we do not reach very great distances. Still we reach a greater distance than one would suppose ; we sometimes reach a mile. In a case of that kind, a man may close the manhole over him and look for a passage of air. He might think there was no air there, but we know there is from the fact that explosions have stopped and that we can dry out manholes. If we stop our plant for a week the manhole will become damp and wet, so that we know we are getting air. In the electric light conduits, the ones that were built prior to the putting of the telephone wires underground, there were laid in with the conduits pipes varying from 12 inches to 4 inches in diameter. At every manhole we would tap an inch hole into it and bush it with a number of bushings. The reason for using a number of bushings is that we can graduate the size of our hole. At first we used a lock-up cock, thinking that it would not be meddled with, but we find that linemen and plumbers shut the air off or let it on and upset our calculations ; so we put these bushings in. The method of putting the air in is simply pressure. We use the Root blowers, in some cases running them with steam engines and in some with gas engines. The gas engine I should like to call your attention to. We have in one station in Forty-second street two 10 horse-power Otto gas engines that have been running night and day for about five years, and those engines have never been repaired, and the cost of running them is about equal to running a steam engine. With a steam engine we would have to take into consideration the cost of an engineer, and in this case we have a cheaper man, so that the increased cost of gas for such plants as we use makes it come to about the same as steam ; we have steam plants to compare it with.

Any time that the gentlemen feel disposed to visit us, we have a plant in Thirty-eighth street, on the west side, and one in Forty-second street, on the east side. Those plants each contain what we call a telephone blower and an electric light blower. In other words, the Board of Electrical Control will not allow us to have any connection between the high and low tension ducts.

Mr. Jellett:—I am a member of the committee appointed yesterday as to uniform specifications and contract. We have been talking the matter over and we would like to have the commitee increased

to five. There are some men whose services and experience would be of great help to us. As the committee was appointed by the chair, I think it is optional with the chair to increase the committee.

The Chairman :—I should be pleased to appoint on that committee Mr. James A. Harding and Mr. E. P. Bates.

If there is any new business to come before the society we will hear it now or we will pass on to the discussion of the different topics.

Mr. Cobb :—It seems to me that we, as a society, will neglect a duty that is an obligation almost if we pass over our first annual meeting without spreading upon our minutes in some form, a vote of thanks that shall express to the officers and others who have worked so diligently in our interests in organizing this society, and getting it into its present shape, our appreciation of their valuable services. I, therefore, move you, Mr. President, that a most hearty vote of thanks be extended to all the officers, managers, and members of the council who have participated in the organization and the conduct of this society from the time that they were appointed up to this final meeting.

Mr. Jellett :—I second the motion. (Motion carried.)

The Chairman :—The society should take some action on Mr. Baldwin's invitation, I think, either to go as a whole, or individually, to see the plant.

Mr. Jellett :—I would move a vote of thanks to Mr. Baldwin for his kind invitation, and I think the members should arrange with him as to the time that will suit him best. (Motion carried.)

Mr. Harding :—It is quite possible that there are as many members present now as there will be during this meeting, and there is a matter which will have to be taken up before we close. The by-laws say : " In addition to the annual meeting there shall be a semi-annual meeting at places designated at the annual meeting." Although we have not been in existence long enough as a society to have made what we can call progress, yet we have made a start and we will have a status in a short time. I do not yet think we are in a position to count very largely upon the value of the semi-annual meeting for this first year. I believe that by concerted action on th new officers, managers, and council, we shall be able to further the interests of the society in the line upon which it has been organized, and upon which its transactions have thus far been conducted, as well without the semi-annual meeting as with it. I make a motion that the semi-annual meeting for this ensuing year be omitted.

Mr. Barron :—I second the motion.

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Mr. Quay :—I think this is a mistake, especially with a young and rather small organization. I think there is a great benefit in meeting as we have met here and discussing different topics in regard to heating and ventilation, and also suggesting ideas in regard to increasing our membership and strength, and I think we make a mistake in not having a semi-annual meeting.

Mr. Carpenter :—I had not heard the matter brought up before at all, but it seems to me that on account of being a small organization, it would be better for the present time to have but the one meeting. If there are two meetings there may be some of us who would go to the summer meeting and who would not be able to go to the other meeting. Now, we are so small at the present time that we all ought to endeavor to make a point to get around to this one meeting, until we get to such a size that we can divide it.

Mr. Jellett :—I think that is about correct. I think it is going to be a very difficult thing with our present membership to get a fairly good meeting in the middle of the summer. Most of us try to get a vacation in the summer. I try to get a vacation and drop my business as far as I can. There may come a time when we will have a large membership where a trip East for a number of western men, or a trip West for a number of eastern men, would be a desirable thing. But I do not think the membership this year is sufficient to warrant a summer meeting, and that the benefits to come from it would not amount to very much.

Mr. Barron :—I do not think it is expedient to have any summer meeting for two reasons. It will put too much work on the officers elected and too much expense on the society. We may in following years have successful summer meetings ; for this year, however, I would not be in favor of it. (Motion carried.)

Mr. Barron :—If you have no objection, I would like to do the same with Mr. Hunting's paper, presented yesterday, or have some other member do the same, as I did with Mr. Waters' paper. The papers presented here should have a certain amount of discussion. I think each and every paper should receive some discussion.

Mr. Quay :—I would like to ask how long we expect to continue this session. I think that is an important matter before we decide to give time to different papers. If we give as much time to different papers as we did to the other papers this morning and take up the topics that have not been discussed, and attend to the rest of the business of the association, it will take two or three days more to get through. I think that matter ought to be considered before we decide to give attention to any of these papers.

Mr. Wilson :—I think very much as Mr. Barron does in regard to this matter. The fact that gentlemen take the time and trouble to prepare these papers obliges us in courtesy to give those papers some consideration. I think if the gentlemen who discuss these papers will kindly bear the fact in mind that we have not much time we will be able to take up the papers and do justice to them and finish our business in a reasonable time.

Mr. Harding :—I think the papers yet remaining undiscussed and the topics can be sufficiently gone over by the end of to-day and I think it would be to the interests of the society not to continue this meeting after to-day. I believe it is better to get up from the table with some appetite, and I would make the motion, if it is proper, that we adjourn this meeting at 1 o'clock to meet at 2:30 and continue until 6 o'clock, and then adjourn for a year. (Seconded.)

Mr. Jellett :—I notice to-day that a number of men who were here yesterday have gone and understand there are a number of others who will go this afternoon. I think myself that it is better to close to-day and confine ourselves strictly to the papers and the subjects before us and discuss them as far as we can intelligently in the time.

The Chairman :—It was the intention of the board of managers that the meeting take up about three days.

It is moved and seconded that when we adjourn at 1 o'clock we meet again at 2:30 and continue in session till 6 o'clock, when we adjourn until the next annual meeting.

Motion was carried.

Secretary Hart read to the meeting the contract made with the American Society of Mechanical Engineers by this society.

Mr. Harding :—If it is in order, I move that Mr. Hunting's paper be immediately read and the discussion on it be proceeded with.

Mr. Jellett :—There is one matter I overlooked. We had an invitation to attend the New York Trade Schools. I think we ought to extend a vote of thanks for that kind invitation. I move you, sir, that a vote of thanks be extended to Mr. McNeil for the invitation.

The motion was carried .

The Chairman :—While they are getting ready for the paper of Mr. Hunting, I think we might take up one or two of the other topics for discussion. No. 7 might be taken up—" Necessity of automatic air and water valves on steam systems."

After discussion of this question by several members the meeting was adjourned until 2:30 P. M.

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AFTERNOON SESSION, THIRD DAY, JAN. 24.

The meeting was called to order at 3 P. M., Vice-president Mackay in the chair.

Secretary Hart read the following telegram from Mr. Charles W. Newton :

BALTIMORE, January 24th, 1895

L. H. HART, Secretary American Society of Heating and Ventilating Engineers, New York.

I positively decline any office whatever. Impossible to attend. Am grateful for honor conferred and wish the society best success.

Mr. Harding :—I would move that the resignation be accepted. (Seconded.)

The motion was carried.

The Chairman :—It would seem to me that it would be policy to refer this telegram to the board of managers for their decision as to how the office shall be filled.

Mr. Harding :—Under the circumstances, perhaps we had beter suspend further discussion for a few moments until the board of managers can get together. They can present this matter probably in five minutes to the meeting. When the maximum number of members are here we can fill this office.

The Chairman :—With that suggestion I will declare an intermission of five minutes and call a meeting of the board of managers.

(Intermission.)

The Chairman :—Is the chairman of the board of managers ready to report ?

Mr. Harding :—There are no express provisions in the constitution with regard to filling a vacancy in any office. The only thing that would seem to cover it is in article 5, section I, which says that the board of managers shall have general control of all the affairs of the society. There is a point that must not be lost sight of in this connection, that Mr. Newton was the president of this society for a brief period, during which brief period this society was incorporated, and his name appeared in the articles of incorporation. We must recognize the fact that he was president and that the annual election was valid. This is not the annual election, but as the meeting has not disbanded and the principal part of the members who attended the meeting are now here, it is thought eminently proper that an expression of opinion should be had on a candidate to fill the position which Mr. Newton has resigned. It has pleased the members assembled at this convention to confer the honor of vice-presidency upon three gentlemen. The honor conferred on the vice-president is equal among the three and

is divided, to some extent, in relation to territory, although in the matter of succession, if the meeting had disbanded, the presidency would naturally fall on the first vice-president. Still, we do not care to begin the year without a president, and it is thought by the board that as the honor has been conferred on three gentlemen as vice-presidents, the honor of being president should be among the three gentlemen, and that the society should declare its preference. Therefore, the recommendation of the board of managers is that the present vice-presidents be placed in nomination for the office of president, to be voted on regularly. We recommend the names of Mr. W. M. Mackay, Mr. Charles S. Onderdonk, and Mr. Stewart A. Jellett as candidates for the office of president of the society.

Mr. Barron :—I can see the complication that confronts the board of managers, but according to your constitution you cannot present the names of three gentlemen. You have to present two. We will have to do this strictly according to the constitution, and that says that there must be two candidates for any office. You must elect them by ballot, and you cannot elect them in any other way. It seems to me that this matter had better be left over for a little while, and that the board of managers had better give the matter a little further consideration and perhaps consult with Mr. Tenney before doing anything, and they might consult with Mr. Newton again. I think that is a more serious matter than it looks on the face, in view of the incorporation. I would suggest that you do not proceed to do anything immediately. Let it go until later in the afternoon. In the meanwhile, the board of managers will have a chance to think about it, and you can consult the lawyer.

Mr. Harding :—I do not think that this method of procedure interferes in any way with the requirements of our constitution. It says : " The annual meeting of the society will be held in January of each year, the date to be fixed by the board of managers 60 days in advance of the meeting. The chair will select a nominating committee, consisting of five members, whose duty it shall be to present to the meeting the names of two candidates for each position to be voted for, all voting to be by ballot, no proxies to be voted." That has all been done regularly. This is not the annual election of officers. This is simply a provision for filling a vacancy caused by the resignation of an officer who was elected at the annual election in the regular manner, and, as I define it, and as it is defined by the board of managers, it comes within the province of the board of managers to fill that vacancy, and out of courtesy to the

members now present we defer to them to arrive at a conclusion. Otherwise the board would proceed without consultation with members to fill this vacancy.

Mr. Barron :—I will perhaps concede, in my present ignorance regarding the constitution, that the first vice-president would succeed the president in case the president declined the office. But there is nothing in the constitution that confers on the board of managers the power to elect a president. Mr. Bates was elected and he declined ; then we had another election and the nominating committee named two candidates to be voted for, and we elected Mr. Newton. Now Mr. Newton declines. In the meantime, you have proceeded with these articles of incorporation. But there is nothing in this instrument which gives the board of managers the power to select the president. In the absence of the president, the vice-president takes his place, and, therefore, in the absence of the president the vice-president remains vice-president and exercises the office of president.

Major Light :—I can hardly conceive that there is a vacancy. This is the annual meeting, and as yet this annual meeting has not adjourned. Among other duties the annual meeting is charged with the election of a president, and as Mr. Barron has just stated, Mr. Bates was elected ; he was present and declined. Then Mr. Newton was elected. He is advised by the quickest available method, and while the annual meeting is yet in session he declines. It is simply declining to take the position. The position is open, and this annual meeting not having adjourned, I fail to see why we may not proceed as before to the election of a president, and by the same means and methods.

Mr. Harding :—I think the fact that the board of managers opened the matter for discussion has been the means of giving them points that are valuable. Mr. Light has made it clear to me and possibly to my fellow members on the board of managers that he is right.

Mr. Quay :—Is it not the place of the old nominating committee to make these nominations?

Mr. Barron :—I do not think there is any question but that this matter goes back to the nominating committee, and they nominate candidates who can be voted for. The only objection is that you do not want to do that without advice. The lawyer is doing something, and you must not alter the conditions until his work is accomplished.

The Chairman :—I would state for Mr. Barron's information that what the lawyer was employed to do has been done, and

there is still a vacancy. It would seem, as members have said, that the position is just this : I have either got to put it back into the hands of the original nominating committee or appoint a committee of five to name candidates for the vacant office.

Mr. Harding read to the meeting the acknowledgment to the Articles of Incorporation.

Mr. Barron :—It is purely a matter of caution on my part. Whether Mr. Newton's name is in the instrument or not, the fact is that we told Judge Tenney that he was the president, where he resided, and all that sort of thing. I do not think we could proceed to fill the office without having a consultation with Judge Tenney. I think Mr. Harding could go down there and find him this afternoon. I do not see the necessity for a tremendous rush about it. Mr. Newton might change his mind.

Mr. Quay :—I understand that Mr. Newton is not one of the incorporators, and it does not make any difference anyhow. I have gone through this incorporation business a great deal. You can incorporate with any officers you please, and if any one of those men resigns, there is a means of filling that vacancy. You do not have to go back to the corporation lawyer or Secretary of State to arrange that.

Mr. Harding :—I would say that Mr. Newton was the president of the American Society of Heating and Ventilating Engineers. When we incorporated he had been elected and his resignation had not been received, and we are legally incorporated with him as one of the incorporators, one of the trustees. We can fill that vacancy without going to the state and asking permission.

Mr. Barron :—Mr. Newton not having accepted the office, I question whether it would be considered that way by persons professionally qualified to express an opinion on the subject. Steam and ventilating engineers giving points about law are very much in the same position of lawyers giving points about heating and ventilation. I associate a good deal with lawyers, but I do not know anything about law, and I do not like to interfere with a doctor, or lawyer, or minister, or any one else, and I do not like them to interfere with me.

Mr. Thompson :—The question would naturally arise, if Mr. Newton had simply been elected and had not accepted, whether he is or was the president of the society.

The Chairman :—Unless it is objected to by the society my ruling would be that it would be in order to appoint a nominating committee of five to nominate two candidates for that office, and I would appoint as such committee Mr. James A. Harding, Mr.

L. H. Hart, Mr. Stangland, Mr. McMannis, and Mr. Barron.

Major Light :—Mr. Chairman, I think we are compelled to go in accordance with the constitution and by-laws, and the nominations would naturally come from exactly the same source that they came from yesterday. That is merely my opinion.

The Chairman :—Were the nominating committee of yesterday present I should certainly refer it to them.

Major Light :—Is there a majority of that committee here?

The Chairman:—There is not. Messrs. Foster, Cryer, and Adams of the old committee are not present. The other two I have appointed on this nominating committee. I have merely added to the committee so as to fill their number to the constitutional number of five.

To facilitate business, while the nominating committee are making nominations, we will take up the topics of discussion. No. 8 was acted upon in discussing Mr. Waters' paper. It would seem that No. 9 would be next in order unless some of the members wish some other topic brought up. No. 9 is : What should we accept as the minimum standard of ventilation for various buildings, and what is the best means to employ to obtain this result?

Mr. Quay :—This was partly covered at least in the discussion this forenoon. It might be well for the time being to take up something we have not considered, and then we might have time to consider this again.

The Chairman :—No. 10 has been touched on. Is there anything in No. 11 for us to discuss?

Mr. Jellett :—That was pretty thoroughly gone over.

The Chairman :—No. 12 comes next: Value of standing committees of the society on tests and standards.

Mr. Quay made a few remarks on this topic.

The Chairman :—If the nominating committee is ready to report we will stop the discussion on this subject and hear their report.

Mr. Harding :—The nominating committee presents the names of Mr. W. M. Mackay, of New York, and Mr. Stewart A. Jellett, of Philadelphia, as candidates for the office of president.

The Chairman :—I would ask the same gentlemen who took the ballots before, Mr. Quay and Mr. Paul, to act to-day.

The society then proceeded to ballot for president.

The Chairman :—The tellers inform me that there has been a ballot cast by an associate member, which is against the constitution. That invalidates the ballot and makes it necessary to have another ballot.

A second ballot was taken.

Secretary Hart :—The whole number of votes cast is 14. Mr. Stewart A. Jellett has 9, and Mr. W. M. Mackay 5.

Major Light :—I move you that Mr. Jellett be declared unanimously elected.

Mr. Harding :—Permit me to read a clause from the constitution: "Fifteen members at any meeting shall constitute a quorum." Are there fifteen members present?

Mr. Paul :—Yes, there are fifteen present ; 14 voted, and there is the chairman.

The secretary called the roll and announced that sixteen members were present.

Mr. Barron :—I would like the 16 active members to walk forward so that we can count them. I do not make out that number.

Secretary Hart :—What is the matter with their standing up.

The members present stood up and were found to number 14.

Mr. Barron :—I think it would be better to wait until late this afternoon. I move that we proceed with the consideration of Mr. Hunting's paper.

Mr. Harding :—I believe that motion is not seconded. I would like to suggest to members present that none of them leave the hall, unless on most important business, for the next two hours in order that we may have this election made good.

The Chairman :—If there is any further discussion on topic No. 12 we will finish that, as we had it under way. If not, we will proceed with Mr. Hunting's paper.

Further discussion of topic No. 12 was followed by a suggestion that a committee on tests be appointed.

Mr. Quay :—I should think it would be well to have a committee appointed to cover both tests and standards, or a committee on tests. I think it would be a very valuable committee to have. I do not know whether this is the proper time for a motion of that kind. If it is I would make a motion that a committee of three be appointed.

The Chairman :—It would seem to me that would come under the head of board of managers and not from the chair.

Mr. Quay :—We appointed a committee on standard specifications right at the end of the discussion.

Mr. Barron :—I beg to differ from the chair about the power of the board of managers. There is no question about this annual meeting having power to appoint as many committees as they choose. No matter how superior the board of managers may be when we adjourn, we are the masters just now. I second Mr. Quay's motion.

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Mr. Jellett :—In article 1, section 4, subdivision 4, of the constitution, we have the following clause : "To establish a clearly defined minimum standard of heating and ventilation for all classes of buildings." Now if this committee is appointed to put into effect that provision of the constitution it covers the whole case, I think.

Major Light :—It occurs to me that that is foreign to this motion. A minimum standard for heating and ventilation is a specific thing by itself, while this is special and aside from that—simply the conducting of tests and standards.

The Chairman :—I do not think that was the intention of Mr. Quay's motion.

Mr. Quay :—Tests was the main point I made. The only question was whether to include tests and standards in one committee.

The Chairman :—Then it is not to carry out section 4, of article 1, of the constitution.

Mr. Barron :—I wish to say, Mr. President, that the late board of managers appointed a committee merely as a suggestion to this meeting. Now, as I understand from Major Light's remarks, Mr. Quay's motion is an entirely different matter; it is simply tests; for instance, radiator tests—anything that differentiates us from mechanical, civil and other engineers. I do not think we have any right to go into steam engineering, or boiler engineering, or anything outside of our specialty. The best example, of course, is a radiator test; indirect radiators for both steam and water, and direct and any other form of radiator possible to be evolved from the human brain—to test those things. This committee, in my opinion, should have authority to make such tests, subject, of course, so far as expense goes, to the board of managers.

The Chairman :—It is moved and seconded that a committee be appointed for the purpose of making such tests as may be for the interest of the society. Is that the way you put it, Mr. Quay?

Mr. Quay :—Major Light explained that quite clearly—the idea of having a standard of tests as well as making tests. The question of determining the heating power of plants, I think, might be settled by having a proper committee on testing and have a formula for tests. A radiator concern, for instance, will get up a place for testing radiators. Their work would cover that line, but the committee should be called in in conference and examine those tests, and if this committee should pass on a test we would consider it as being authoritative and approved by the committee representing this association. I do not know just what they might find it

necessary to test before they got through. They might have to test a good many.

Mr. Barron :—These committees might cooperate. But this other committee has so much to do—to establish a minimum standard ; that is a big contract and should not be mixed in with the other matter. Both are important, but I think it would be better to have this committee you are acting on now strictly a committee on tests, and the other committee could be taken up afterwards, if we settled on this.

The Chairman :—The present committee is merely to appoint a committtee on tests, to make such tests as would be of interest to the society . .

Mr. Barron :—I would ask Mr. Light if it was his idea to have a committee to make tests in the name and under the supervision of this society and report to this society.

Major Light :—That is clearly my idea ; yes, sir.

The motion was carried .

The Chairman :—I will leave the appointment of the committee until later in the meeting.

Mr. Barron :—I move you, sir, that a committee be appointed by the chair, the number to be at the discretion of the chair, to carry out as nearly as possible the provisions of sub-section 4, of section 4, of article 1, of the constitution, and report to this association at the next annual meeting

Seconded by Mr. Harding.

Mr. Barron :—Before you put the motion I wish to say that all these motions are carried by courtesy. It is not expected that any member who is voting on these things would ever question them. But I think it would be well for you to delay the appointment of such committees until there is a full quorum.

The Chairman :—It is moved and seconded that a committee be appointed by the chair, the number to be decided by the chair, to carry out as far as practicable sub-section 4, of section 4, of article 1, of the constitution.

The motion was carried.

Mr. Barron :—I move now, Mr. Chairman, that the legislative committee appointed by the board of managers be read off.

Secretary Hart read the resolution appointing the committee.

The Chairman :—At a later meeting their duties were curtailed. I think if the secretary will read that it will make it clearer.

Secretary Hart read as directed.

Mr. Barron :—Now I move, Mr. Chairman, that the powers of this committee appointed by the board of managers be extended,

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and that the chair appoint a committee composed of the gentlemen who are named to carry out as far as practicable sub-section 5, of section 4, of article 1, of the constitution, namely, "To favor legislation compelling the ventilation of all public buildings in accordance with the standard of this society," and that the chair be further empowered to replace any gentleman who declines to serve on that committee with another.

Mr. Jellett :—I second the motion, but I think the committee is too numerous. When you have a committee scattered all over the country, consisting of nine or ten men, it is a very difficult thing to get that committee in working shape. My own experience with committees is that a small committee of three or five members will do more work than a committee of ten. You will find that it is a mistake to have a committee pretty well scattered over the country with the idea only of getting an expression of opinion.

An expression of opinion is one thing, the executive work of the committee is quite another, and if we had a committee that would work together and frame the proper form of bill, after that the individual members can be called on to use their best efforts to have the bill endorsed in the different states. Of course, you know the laws in the different states vary considerably. I do not know what the conditions are in New York state, but in Pennsylvania we have practically three departments under the government with which we would have to co-operate. First, the Bureau of Charities and Correction, whom we would have to approach respecting all the institutions receiving state aid. They are all subject to the supervision of the Board of Charities, and all matters relating to the welfare, health, and comfort of the occupants of those buildings come to them for consideration. Then we have the Factory Inspection Act, which regulates the number of closets, urinals, etc., in factories and the number of employees in a building, and the age of children employed in factories. Then again we have the state Board of Health in times of epidemic and in the matter of contagious hospitals. So we would have to have the joint approval of those three boards in order to carry out fully any legislation of that kind. If we went before the legislature with a bill having the endorsement of those three bodies there is no question that it would pass. If the Factory Inspection Department opposed a bill of that kind, then the bill would have to be modified so as to affect only such public buildings as were covered by the other two departments. I think, if the committee frames in outline the manner of proceedings, it then becomes the

duty of each member of this society to help that committee as far as possible in their particular locality.

The Chairman :—As I understand, you second the motion but suggest the reduction of the number of members of the committee?

Mr. Jellett :—Yes, sir.

Mr. Barron :—I would like to read my motion off as I have written it down. I move that a committee of five be appointed to frame a bill in outline to carry out the provisions of sub-section 5, of section 4, of article 1, of the constitution (and we will incorporate that clause of the constitution), and that the gentlemen appointed by the board of managers on such a committee last year to be continued, those declining to serve to be replaced by the president at his discretion, and the said committee to report at the next annual meeeting.

Mr. Harding :—There is a little conflict in my mind as to how the board of managers can appoint a committee for this society.

Mr. Barron :—Then I will take out of that all reference to the board of managers.

Mr. Harding :—I would amend Mr. Barron's motion that the selection be made from the gentlemen recommended for that committee by the board of managers to fill this committee to be appointed, however it is to be appointed, for the purpose aforesaid.

Mr. Barron :—I accept that. The object as I understand it is to get rid of the implication that the board of managers has any right to appoint any such committee. I think that is correct, and I accept his amendment. It does not alter the resolution in any way.

The Chairman :—There is no amendment then as I understand it. It is only Mr. Barron's motion with Mr. Harding's suggestion.

Secretary Hart :—Now the motion reads :

"Moved by Mr. Barron that a committee of five be appointed to frame a bill in outline to carry out the provision of sub-section 5, of section 4, of article 1, of the constitution, namely, to favor legislation compelling the ventilation of all public buildings in accordance with the standards of this society."

The motion was carried.

Mr. Harding :—This committee is for the purpose of favoring legislation compelling the ventilation of all public buildings in accordance with the standard of this society. This committee is to report next year. What is the standard of this society?

Mr. Jellett :—There has been a committee appointed on the standards and a committee to carry into effect legislation. Neces-

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sarily those two committes would confer. As they both report at the next annual meeting they will certainly come together before that time, so that the committee on legislation can make their report after conference with the committee on standards.

Mr. Harding :—It may be that I was out of the room when that committee was appointed. I understood that was a committee on tests.

Mr. Jellett :—Two committees were appointed.

Mr. Quay:—I think we have a quorum present just now.

The Chairman :—Is it the wish of the society to proceed to the election of a president?

Major Light :—I move you, sir, that we proceed to the election of a president.

The Chairman :—It will be necessary to count the number present.

The secretary called the roll and announced that 14 were present.

The members present were then requested to rise, and 15 were counted.

The Chairman :—For the information of the gentlemen who came into the room since the last ballot I would say that an election is made necessary by the resignation of Mr. Newton as president. We are now to vote for a president. The secretary will read the names of the candidates.

Secretary Hart :—They are Mr. W. M. Mackay and Mr. Stewart A. Jellett.

The Chairman :—The members will prepare their ballots, voting only for one candidate.

A ballot was then taken

Secretary Hart :—The vote for president is as follows : Whole number of ballots cast 15, of which Mr. Stewart A. Jellett received 10 and Mr. W. M. Mackay 5.

Major Light :—I move that Mr. Jellett be unanimously elected.

The motion was carried, and at the request of Vice-president Mackay Mr. Jellett took the chair.

President Jellett :—Gentlemen, I want to thank you very much for the honor conferred upon me. I feel a great interest in the society, as you doubtless know, because I believe there is a field for a society of this kind in this country, and there never has been a time when it was more needed than now. I have felt along that an older man, a man of more experience, should occupy the chair. That, of course, rests with you, and you have decided. I will only say now that I shall do everything in my power to further the interests of the society. I feel that it wants to be considered

entirely from an engineering standpoint; that we want to consider means and methods for the development of the business of engineering, both for heating and ventilating buildings in the different methods employed to-day, and in the improvement of those methods. Anything we can do in the way of improving the science of heating and ventilation contributes so much to the public welfare and the public health, and it is an ennobling work to which all of us should lend our best efforts aside from any business consideration. I thank you, gentlemen, and ask that you will give me your hearty support in every way, and we will try to bring this society to the position that I think it should occupy.

Mr. Thompson :—I move, if it is in order, that we now proceed to elect the third vice-president of the society.

The President :—It is necessary for the nominating committee to name candidates for that office, and to enable them to do that I declare a recess of five minutes.

(Recess.)

Mr. Harding :—The nominating committee present as candidates for the office of third vice-president the names of D. M. Quay, of Chicago, and Prof. J. H. Kinealy, of St. Louis.

Mr. Quay :—I think you had better appoint another teller.

The President :—I will appoint Mr. Wilkinson in Mr. Quay's place as teller.

A ballott for third vice-president was then taken.

The President :—There have been 14 votes cast, which is less than our quorum.

Mr. Harding :—Pardon me for suggesting that while the constitution says that 15 constitutes a quorum, it does not say that 15 votes shall be cast.

The President:—But one of our members has gone from the room ; he may be in in a few minutes.

A member here entered the room and was about to vote, when the president informed him that the ballot had been declared closed, and that if the member was not present at the time the vote was cast it would be necessary to have another ballot.

The member said that he was not present at that time, and a second ballot was taken.

Secretary Hart :—The whole number of votes cast was 15. D. M. Quay received 13 and J. H. Kinealy 2.

The President :—D. M. Quay has been elected third vice-president of the society.

Mr. Stangland :—I move that the nomination be made unanimous. (Motion carried.)

Mr. Harding :—To conform with some technicality of the law, the attorney employed by the board of managers said that he desired, on the day on which the papers were filed for incorporation, that a motion be made that the secretary be instructed to cast a vote electing to the various offices we had to fill the various condidates who had previously been elected in our usual manner, and I make a motion that the secretary be instructed to cast such a ballot.

The motion was carried.

The President :—Mr. Secretary, you will please cast a ballot in accordance with the motion.

Major Light :—Mr. President, the business that we left when we went into these promiscuous motions was, I believe, the discussion of topic No. 12.

Mr. Barron :—I think several here have prepared themselves a little to discuss Mr. Hunting's paper. It is hardly fair to Mr. Hunting and ourselves not to give it some consideration.

The President :—Gentlemen, if that is the sense of the meeting, we will take up the discussion of Mr. Hunting's paper on the use of exhaust steam for heating.

Mr. Hunting's paper was then discussed.

The President :—If there is no further discussion of this paper I wish to announce the special committees in compliance with your resolutions.

As a committee on tests, the number of which was limited to three by the resolution, I appoint Major H. E. Light, A. A. Hunting, and E. P. Bates.

Committee on standards, H. J. Barron, William McMannis, and J. H Kinealy.

Committee on compulsory legislation (the resolution calls for five), William M. Mackay, J. A. Harding, L. H. Prentice, H. D. Crane, and B. H. Carpenter.

Gentlemen, I am compelled to take the six o'clock train home to-night, and I think I will have to leave you now, and I would ask Mr. Mackay to take the chair.

Major Light :—Before the president vacates the chair I wish to say that it would be quite inconsistent for me to accept the appointment of chairman of the committee on tests, because of the isolated portion of the country I operate in, being so far away from the majority of those interested.

The President:—I differ with Major Light in that respect. I think if you take three widely separated men, they are dealing with different conditions in different parts of the country. I think they can

compare tests by correspondence to a great extent, and I always feel that the mover of a resolution has a particular interest in that resolution and is always more willing to do work in that particular direction. I think it is the usual practice that he should take the chairmanship of that committee, and I would particularly request that Major Light act on that committee, because I think he is very much interested in the subject.

The president then withdrew and Mr. Mackay took the chair.

Mr. Quay :—I move that we reconsider the motion made today to adjourn at six o'clock, and that we have a continuous session until we get through with the business of the society.

The motion was carried.

The Chairman :—We have got to topic No. 12. Is there any other business to bring before the society.

The next topic is No. 13, "What is the proper proportion for cold air inlets to hot air furnaces?"

Mr. Barron :—I move that we pass that.

The Chairman :—No. 14 is "Efficiency of extended surface in steam and hot water radiators."

Mr. Stangland :—I should be pleased to hear from some of the members on that topic.

A discussion of topic No. 10 sent in by Mr. H. B. Prather was read by the secretary.

The Chairman :—Is there any further discussion on topic No. 10?

There is not, and if there is no other business we will return to No. 13. Is there any discussion on that subject? I understand that it was presented by Mr. Wilkinson. If he is present we will be pleased to hear from him.

Mr. Wilkinson made a few remarks on topic No. 13, after which a recess of ten minutes was taken.

The Chairman :—Do any of the members wish to go back to some of the previous topics? We have got through with No. 13. Is there any business to bring before us?

Mr. Quay :—There was a committee appointed on uniform specifications to confer with the Master Steam Fitters' committee on the same question. Mr. Wells, the chairman of their committee, is here. I think we would like to hear what they have done in that respect, especially with regard to a uniform contract.

Mr. Wells :—Mr. Chairman and Gentlemen : At the last annual convention of the Master Steam and Hot Water Fitters' Association of the United States it was recommended that a committee be appointed to prepare a uniform contract relating to heating appara-

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tus, having more especial reference to the operation of the clause guaranteeing a certain degree of temperature, and its results to us contractors in the matter of deferring our payments, etc. The report of this committee, or the opinions of this committee, and the consensus of opinion from many of the leading members of our association, has been digested and a uniform contract has been prepared and will be published on the first of February and circulated to every member of the steam fitting trade in the United States. If you will furnish me with a list of your members I will be glad to send to each of them a copy of this contract. The contract in its present shape will be printed in quantities to suit the purchaser if orders be obtained for it. The contract is not a finality as it stands. We should be glad to see it improved upon if it can be, and will be glad of any criticism as to any of its features which may be sent to us. Of course, it is a difficult thing to prepare a documnet that will suit all sections of the country, the status of business in all sections of the country, and the individual desires and inclinations of our own members who are contractors. But the committee had in view the fact that most of the contracts which are signed are one-sided; that is, the preponderance of advantage, the control, whatever you may call it, is all, or nearly all, on the side of the people for whom we do our business, and as a result of that many contractors are, as they think, imposed upon.

Money has been retained, clauses in a contract have been interpreted to their disadvantage, and it has been sought by means of a uniform contract to obviate, if we can, these little difficulties. The salient features of the contract on which more particular stress is laid has been, firstly, that the agreement is to heat the man's premises—not his premises, but the rooms and sub-divisions of his premises in which he desires heat—to a certain fixed temperature which is agreed upon, and the contractor by this contract holds himself liable at any time to make that good; but in consideration of that fact the owner is to pay to the contracter, when his job is done, his money, instead of retaining it until the contractor demonstrates that fact.

Another point that is covered, and one that has been found to be objectionable, is that of interpretation of plans and specifications. This contract provides that any interpretation made by the architect or by the heating engineer, or by any one who has charge of the work, shall be immediately executed by the contractor without cavil. But that if the question is raised as to additional compensation that the same shall be left to arbitration.

Those, I think, are about all the features of the new contract except that it covers the insurance question, in which there has been some doubt as to the responsibility. In this case it provides that the contractor shall be responsible for his materials until they are in place in the building and shall turn over to the owner a proper heating or ventilating apparatus, as the case may be, subject to no other clause except damage by fire. That means that the owner must protect his own property by insurance and that when the contractor delivers his goods within the building, if there should be an accidental fire, that he will have compensation for them.

The Chairman :—I am sure we have been very much pleased to hear from Mr. Wells.

Major Light :—May I make one or two inquiries ? First, as to the condition the proposed form would carry for the payment for extras.

Mr. Wells :—With regard to extras this contract provides, first, that no additional work would be done without a written order and consequently that extra work should be paid for pro rata with the conrtact instead of being retained as is often the case until the contract is finally completed and made a subject for auditing and an excuse for retaining final payment.

Major Light :—Second, the security for apparatus put on owners' premises and the lien that the person would hold.

Mr. Wells :—This contract has provided a clause to govern that which has been held by some of our members as being one that it would be impossible to enforce. On the other hand it has been held in the courts of this state that a similar clause is a subject of mutual contract; that is if the owner signs such a contract with this clause in it and suffers from any damage that may occur from his failure to comply with the clause—the clause in question is this, that if default be made in any of the specified payments the contractor shall have the right to stop work on his contract, withdraw his unused materials and workmen. and keep them withdrawn until such payment is properly made, or at his option he may cancel the contract entirely.

Major Light :—My idea goes a little farther than that. We will suppose, for instance, that it is a sub-contract and the steam fitting is a part ; what is the security as against the other party not being entirely responsible or the possibility that he is not ?

Mr. Wells :—There is no security for that, and in my opinon it is impossible to give any such security. A man taking a contract as a sub-contractor has his own remedy. If he is dissatisfied with the contractor with whom he contracts he can require security

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of the owner or the retention of the money by the owner the same as he does now. But I see no necessity of incorporating any clause in the contract that would cover that part. The sense of the Master Steam Fitters' Association is that they do not desire to be sub-contractors. We are endeavoring in this town here to have municipal work made the subject of separate contracts. Whether that will be accomplished or not I cannot say.

Major Light :—In our company contracts in Michigan we insert a clause giving us a lien upon the apparatus until the final payments are made. Now there have been one or two decisions that justify that and protect the contractor. I will give you an instance. Two years since we put the radiators in the Hollister Block, at Lansing, Michigan. Last spring Mr. Hollister became involved. Some $750 had not been paid and we continued to hold it on that lien. Mr. Hollister transferred the property to Mr. Farwell of Chicago, and it was decided that that account would have to be settled before a clear title could be given to the property.

Mr. Barron :—I would like to ask Mr. Wells if he proposes to have the co-operation of the architects and builders, and if there is a practical way of putting it before them, or what the intention is as to the execution of this new contract; how are we going to use it and adopt it in our business ?

Mr. Wells :—The Master Steam Fitters have not considered that question. In all probability the contract as written will be attached to a form of proposition in which we state that we will do certain work for so much money in accordance with the contract enclosed. The idea of the Steam Fitters is that if it be generally adopted they will take the initiative in introducing it where they can. I do not think it will be presented to the American Institute of Architects. I know that copies will be sent to most of the architects. If criticised by them their criticisms will have the best of attention, because they are the people who give us our business, and they are the people we want to conciliate if possible.

The Chairman :—Is there any further discussion on this question ?

If not we will go on with the topics. Topic No. 14 is the next on the list, "Efficiency of extended surface in steam and water radiators."

Mr. Quay :—I think that was pretty well discussed yesterday.

The Chairman :—We will take up No. 15 then, "The merits, if any, of vertical over horizontal circulation in hot water heaters."

Mr. Barron made a few remarks on this topic, following which the chairman announced that the ninth topic had been passed by.

Mr. Harding :—There was an important point in No. 3 which was passed for future consideration : "The average amount of water condensed per 100 square feet heating surface per hour, in the different manners in which heating coils and radiators are erected."

The Chairman :—We would be pleased to take it up now if the members wish to discuss it. Does any one wish to say anything on that topic or under No. 9? If not we will take up No. 21.

Major Light :—I should think the question was not very definite. The thought occurred to me when we came to that and also with respect to No. 9, that it would take considerable time to digest the matter.

The discussion of topic No. 21 was then taken up, followed by the motion below.

Mr. Barron :—I move that we adjourn.

Major Light :—Before that motion is put I would like to say that it appears to me, in order to accomplish the most important results to the country at large, we being incorporated in this state, that there might be some way of going through the country in some manner and uniting the engineers of the country at large in some way in connection with our society. It occurred to me that a matter that might be thought of before we meet again is that of auxiliary organizations which might possibly exist under this as the parent national organization and so enable us to reach into other localities.

Mr. Harding :—I think this is a society of engineers and not a society of trades people. The society whose rooms we occupy has not found it necessary to have a society of auxiliaries, nor has the society of Civil Engineers. I acknowledge the point the gentleman makes, but I belive we want to concentrate the knowledge of the engineers of this society all in one direction and advance it, as we can by having this society a unit of force.

Mr. Quay :—Might it be proper to take an expression of the meeting in regard to the benefits we have derived from this meeting? For myself I would say that I have been very highly pleased and have received a great deal of instruction and education. I have been much pleased with the harmony that has been manifested in our discussions and I am especially pleased with the interest that has been shown in the discussion of the different topics. These are educating things, and it might be well for us to give an expression of our appreciation of them at this meeting and of the benefits derived from the meeting and the encouragement we have to go forward in this line.

Mr. Barron :—I believe everybody who has been connected with

the organization at any time has been delighted with the results of this meeting. It has been satisfactory, I think, to everybody. There has been perfect harmony and good feeling, and I think the discussions have been interesting and valuable and are of great value to the whole community. All the gentlemen that I have met —and some of them could only come here for a few minutes—have all expressed themselves as being highly gratified with what was going on and the excellent manner in which everything was conducted.

Mr. Harding :—If it is proper, Mr. Chairman, I would like to make a motion that it is the sense of this meeting, and the personal belief of each one, that we have attained, to the full limit of our expectations, that status as a society which we hoped to reach at this meeting.

The motion was seconded by Mr. Barron and carried unanimously.

On motion of Mr. Harding the meeting adjourned.

II

PRESIDENT'S ADDRESS.

BY E. P. BATES, SYRACUSE, N. Y.

(President of the Society, Sept., 1894 to Jan., 1895.)

Gentlemen and members of the American Society of Heating and Ventilating Engineers: I welcome you to this our first annual meeting. The purposes for which this society was formed are commendable in every respect. If we carry out the wise provisions which are named in the preamble to our constitution and by-laws, we shall become public benefactors.

We need to look backward but a very few years to find that our profession was unknown. The rapid strides of modern civilization have created many new professions, and ours among them. There is a wide field open before us, and it yet remains to be seen how well we will occupy it. The child is born, and it gives great promise of a grand future.

I notice the following in the third clause of the preamble: "The maintenance of a high professional standard among heating and ventilating engineers." This is the proper basis on which to found this society. In order to carry out these sentiments we need to gather about us men devoted to the work; men of character and reasonably ambitious of success; men who will think, study, and work until they see the fruition of their hopes. We need also, in this infantile state, to avoid adding to our number any who are not really engineers in our acceptation of the word.

In a new society there is always a temptation to get numbers. This is commendable, provided you confine your efforts to those fully qualified to associate themselves with you; those whose interests are identical with yours. I would prefer to work with a society that only counted ten members, and that ten fully banded together for a purpose, than to number a thousand and have divided interests. Many of us are still interested in contracting and mechanical construction, but, as eligible members of this society, we can well afford to lay that aside for a day and look at heating and ventilating from a professional standpoint only.

I now charge you, as you love the cause in which you have so recently launched your bark, to look well to your applications for membership, as the growth and perpetuity of this society rests upon this fully as much as on any other proposition. In regard to legislation which may in future be shaped by this society, I would say that the field is broad and but little occupied.

The State of Massachusetts seems to have taken the initiative in enacting wise laws and regulating the construction and ventilating of public buildings. Those laws are too voluminous for me to quote from at this time, but I would suggest that each member possess a copy of them and become thoroughly familiar with their text. I believe we should not cease our labors when public buildings are thoroughly warmed and ventilated, but our zeal for a good cause should eventually take us into every building which shall be constructed for any purpose.

When any class of men have given continued study to a certain subject, and have evolved a practical line of action, it is not the time to sit idly by and fold their hands in self-complacency, but their knowledge should be given to the world, forced upon it against its will, possibly, in the beginning, but received with gratitude when the service is partially appreciated.

There are cases where factories and work shops are fairly well ventilated, but in comparison they are rare. This is not always because the owner is unwilling to ventilate his building, but usually because he has not given the subject any attention. He is probably engrossed in the details of his business, and would not know how to begin, if he wished, to ventilate his building. At this point a member of our society could render him an important service.

There is another class of buildings which need our attention, but so far as I have been advised it has been largely overlooked as of little consequence. I refer to the tenement house in our large cities. You may hold that in the majority of cases the occupant does not desire any ventilation, but this does not affect the merits of the case. We should take the matter in hand and bring out a system which will be for the good of the masses.

Every family has the right to have an abundance of good fresh air, even if they are not aware of their rights. I hereby suggest that this be one of the first problems which we handle, and, if possible, secure such legislation as will compel every person or corporation who shall in future erect a tenement house to connect each room to an individual ventilating flue, to be not less than eight inches internal diameter, round in form, and preferably of

glazed tile built in the walls of the building. You may think this a trifling matter, but I assure you that if we, as members of this society, accomplish this much within the next ten years, and do not make any advances along any other line, we shall have achieved a glorious reward for our labors. We shall find, however, that we cannot labor for those of our race who live in the most humble homes without having our work redound to the benefit of the entire race.

Ventilation comes next to godliness, and must necessarily precede the manifestation of the latter, so I hold that in the next decade one of the great human benefactors will be the man or the body of men who make it possible for their fellowmen to be more cleanly in their surroundings. Our work, however, will not stop with any class; it will benefit all classes, and the amount of benefit received will be commensurate with the labor expended upon it.

In order to carry out all the objects of this society, we shall need, first, the hearty co-operation of all its members; we shall need, further, a practical and intelligent devotion to the purposes for which we are organized. With these points carefully covered by each member, there is a work before us which never has been thoroughly done, but will be accomplished by the members of this society, to their credit and the good of the race.

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III

DETERMINING THE HEATING POWER OF HEATING SYSTEMS.

BY J. H. KINEALY, ST. LOUIS, MO.

(Member of the Society.)

It has always seemed to me that the requirements in a contract for a heating system that makes the contractor wait for his money until the system can be tested in zero weather, in order to determine its heating power, is a bad one in every way.

If the plans and specifications have been drawn up by a consulting engineer not in the employment of the contractor, the engineer is responsible for the proper working of the system, and the contractor, in such a case, is only responsible for the work being done in accordance with the plans and specifications.

Where there are no plans and specifications upon which contractors are asked to bid, but each contractor is expected, or asked, to furnish his own plans from which to work, it is but reasonable that the owner should be given either a complete set of plans and specifications that he may submit to a consulting engineer for advice, or a guarantee of some kind as to the heating power of the plant.

Very few of the small heating systems put in dwellings have any very elaborate plans drawn for them, and many large plants are put in without any specifications at all. This, of course, is the natural result of the desire, on the part of the owner, to avoid the cost of plans and specifications. He therefore goes to a firm of contracting heating engineers and tells them he wants his building heated by steam or hot water, as the case may be. The contractors send a man to look at the building or the plans of the building, and to make a rough sketch of what will be required ; this sketch may or may not be somewhat elaborated in the office, but, whether it is or not, it will serve as the basis of the bid for doing the work. The contractor knows the owner does not care for any elaborate plans and specifications, and, therefore, as he should from a business point of view, he spends as little money upon them as possible, and makes only such drawings as are absolutely necessary to carry out the work. Another reason why the contractor does not

get up more elaborate drawings than are absolutely necessary for himself is that he is not sure the owner will want the work done after the bid is made ; it may be, the owner finds he cannot afford to have the work done at all, or that he has received a cheaper bid from some other firm.

The owner desires only that the building shall be heated during all kinds of weather, and that the cost of the plant shall be as small as possible ; and as custom in most parts of the country has decided that a heating system of a buliding shall be considered as adequate if it will keep the temperature of the air in the building at 70 degrees F. during zero weather, he asks the contractor to guarantee the plant to do this.

The contractor guarantees that the plant he proposes to put in the building will keep the temperature inside at 70 degrees F. when it is zero degrees F. outside ; puts in the plant, and then, hardest part of all, waits until zero weather to test the plant and get his money.

In order to avoid the waiting for zero weather on the part of the contractor, I desire to propose a scheme for determining the heating power of heating systems during weather when the temperature is above zero.

It is assumed, as the basis of the scheme, that the heat lost through the walls and windows of a building during an hour is directly proportional to the difference between the temperature of the air inside the building and that of the air outside ; also, that the heat given to the building in an hour is directly proportional to the difference between the temperature of steam or hot water in the radiators and that of the air inside the building.

The total amount of heat lost by the building per hour is given by the equation

$$H_1 = a\,(t_1 - t_2)$$

a is the total heat lost per hour per degree difference in temperature.

t_1 is the temperature of the air inside of the building.

t_2 is the temperature of the air outside of the building.

Also, the total amount of heat received by the building per hour is obtained from the equation

$$H_2 = b\,(t_3 - t_1)$$

b is the total heat received per hour per degree difference of temperature.

t_3 is the temperature of the steam or hot water in the radiators.

t_1 is, as before, the temperature of the air inside of the building.

t_3 may be very little greater than the temperature of the steam

in the boiler, or it may be much greater, depending upon the length of the pipes, and upon the way in which they are protected.

Now, after the system is in the building, it is evident that the heat lost per hour must be equal to what is received, if the temperature inside remains constant, and, therefore,

$$H_1 = H_2, \text{ or}$$

$$a\ (t_1 - t_2) = b\ (t_3 - t_1).$$

From this we have,

$$\frac{t_3 - t_1}{t_1 - t_2} = \frac{a}{b}$$

Since the building cannot change, a cannot change ; and since the heating system is supposed to be always the same after it is put into a building, b cannot change. Therefore, for the same heating system in a building, we have this proposition, which always holds good whatever may be the value of t_1, t_2, or t_3 :

The result obtained by dividing the difference between the temperature of the steam or hot water in the radiators and the temperature of the air inside the building, by the difference of temperatures of the inside and outside air, always the same quantity for the same building and heating system.

While this proposition is not exactly true, it is true enough for all practical purposes, and may be taken as true without any great error. It is evident, also, that the proposition refers only to "direct" systems of heating and not to indirect systems.

Now, let us assume that our standard temperature for inside air is 70 degrees ; that our standard temperature for outside air zero degrees ; and that the temperature of the steam or hot water in the radiators shall be t_4, when the inside air is 70 degrees and the outside air is zero degrees. Then, from the proposition just given, we have

$$\frac{t_3 - t_1}{t_1 - t_2} = \frac{a}{b} = \frac{t_4 - 70}{70}$$

From this equation we get,

$$t_3 = \frac{t_1 \times t_4}{70} - \frac{t_1 (t_4 - 70)}{70}$$

In this equation, it must be remembered, t_4 is the guaranteed temperature of the steam or hot water when the temperature of the inside air is 70 degrees and that of the outside air is zero degrees ; t_1 the temperature of the inside air, when the outside air is t_2 and the temperature of the steam or hot water is t_3.

To show the use of the equation assume the following example :

A contractor agrees to put in a heating system that, with five pounds of steam by the gauge, will keep the inside air at 70 de-

grees when the outside air is zero degrees. He makes a test of the heating power of the system when the outside air is at 10 degrees, and with a gauge pressure of three pounds of steam keeps the temperature of the air inside at 75 degrees.

Here we will assume that the temperature of steam in the radiators is that corresponding to the pressure in the boiler; then t_4 is 227, the temperature corresponding to a gauge pressure of five pounds; t_1 is 75; and t_2 is 10. Putting these values in the equation for t_3 we get,

$$t_3 = \frac{75 \times 227}{70} - \frac{10\,(227 - 70)}{70} = 222.5$$

The gauge pressure corresponding to 222.5 degrees is about $3\frac{1}{2}$ pounds, so that, as the building was heated during the test with a gauge pressure of three pounds, the system would seem to have a slightly greater heating power than called for by the contract.

In the case of open hot water systems of heating the test may be run with the outside air at almost any temperature, as the hot water in the heating system may have any desired temperature less than 212 degrees, and not run the temperature of the inside air above 70 degrees, while in the case of low pressure steam systems the test cannot be made when the outside air is much over 10 degrees without running the inside temperature up to 80 or 90 degrees during the test.

I have assumed that when the temperature of the outside air is zero degrees and that of the inside air is 70 degrees, the temperature of the water in the radiators will not average more than 200 degrees, the temperature of the hot water entering will be 210 degrees, and that of cold water leaving the radiator will be 190 degrees, and have calculated the following table showing what the average temperature of the water in the radiators ought to be, in order to keep the inside air at 70 degrees, for different temperatures of the outside air

TABLE I.

Temperature of Outside Air.	Average temperature of Water in Radiators.	Temperature of Water entering the radiators for a fall of 20°.
0	200	210
5	191	201
10	182	192
15	172	182
20	163	173
25	153	163
30	144	154
35	135	145
40	126	136

A custom of reducing the heating power of systems to a common standard would be somewhat similar to the custom that now prevails among mechanical engineers of reducing the evaporative power of boilers to a common basis. Tests to determine the evaporative capacities of boilers are made under widely different conditons of gauge pressure and temperature of feed water, but all water evaporated is reduced to "water from and at 212 degrees." I propose, therefore, that in determining the heating power of heating systems tests be made and the results of all tests be reduced to standard conditions.

The standard condition for hot water systems shall be :

An average temperature of 200 degrees in the radiators to keep the inside air at 70 degrees when the outside air is at zero degrees.

The standard condition for low pressure steam shall be :

A pressure of five pounds, by the gauge, in the boiler to keep the inside air at 70 degrees when the outside air is at zero degree.

If tests were made to determine the heating power of direct radiator heating systems, and were reduced to the proposed standard conditions, the profession would soon acquire a lot of valuable data as to the required ratio of heating surface to cooling surface for various conditions of exposure and various classes of building. I can see no valid reason why such tests should not be made upon heating systems, and their heating powers reduced in the manner proposed. Such a method of determining the heating power of plants would undoubtedly be of value to the contracting heating engineer, as he would not then be obliged to wait for zero weather in order to determine whether or not the heating power of a plant was as guaranteed.

Below is given a table showing the gauge pressure required to heat the air inside of a building to different temperatures for various temperatures of outside air, and the heating power be equivalent to that required to heat the same building to 70 degrees in zero weather with steam at five pounds by the gauge.

TABLE II.

Temperature of outside air.	Gauge pressure of steam in the Boiler for Inside air at a temperature of,			
	70°	75°	80°	85°
0	5 lbs.	11½ lbs.	20½ lbs.	———
5	1 "	7 "	14 "	———
10	———	2¾ "	9 "	16¾ lbs.
15	———	———	4½ "	11 "
20	———	———	½ "	6¼ "
25	———	———	———	2¾ "

DISCUSSION

Mr. J. J. Blackmore :—This, I think, is a very important paper and one to which this society can very well afford to devote some time. It seems to me that the first thing to determine is whether the author's premises are correct. The basis assumed is that the amount of heat lost will be directly in proportion to the difference between the temperature of the air inside the building and that of the air outside. If we can determine that, so that the limit of error will be within bounds, the scheme as laid out here by Mr. Kinealy is very commendable, and I think we should all make some efforts, and each one should make his own private test, to determine by his own efforts whether the premises set forth are correct. The formula given for determining the value of this plant, so far as steam goes, seems to me to be almost above criticism ; that is, assuming that the premises are correct. That for the hot water does not seem to go quite far enough to determine the value of the radiators as far as the heating of the room. But it would not determine the power of a heater unless there was some standard by which we could test the temperature of the room in the same manner as the steam. The main thing is to determine whether the premises are correct, and I would like to hear a free expression from the members as to their experience. Of course, we know that a larger proportion of heat is lost the higher the temperature. At the same time, it would seem if we have a higher temperature for the house that ought to compensate for the temperature above zero on the outside. But experience shows that more heat is lost by high temperature, both with regard to radiation and the circulation of the air. But how far that would apply to the temperature of a room at, say, 80 or 90 degrees, is a matter I am not quite satisfied on yet, and I would very much like to hear the experience of the members of the society.

Mr. Wilson :—I think that is a matter of great importance to our members. There are very few that have had anything to do with installing plants but have experienced considerable trouble in the settlement of plans waiting for zero weather. This has been used as a handle by a great many to put off the day of payment, and I think a discussion by those who are competent would throw some very good light on that subject.

Mr. Quay :—I notice in the paper it speaks about the proportion of radiation. I do not see that it states much about the construction of the building. We find in practice that the construction of

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the building has a good deal to do with the amount of radiation required. But you cannot figure on a regular basis in proportioning radiation unless you know how the building is going to be constructed, how the windows are, whether they are going to be open, whether the air is supposed to come through the windows with high velocity, and all those questions. Of course, engineers do know, to a certain extent, from the plans and specifications of a building in general, what kind of a building they are to heat. But this question is, I think, quite important, especially when it comes to a contractor guaranteeing a job. They usually have some kind of a guarantee. After the specifications and plans are made a certain guarantee is required of the contractor. I would like to hear that question discussed a little.

Mr. Jellett :—I think the question should be discussed. It is a very important one. The paper gives formulæ for getting certain results, but as Mr. Quay has just said, it gives no description of the building into which such a system is to be put and the conditions under which it is to be operated, both of which have a bearing, of course, on the results obtained. I think it is in Schumann's book that there is a table given which is not entirely correct, I believe, but it marks the way toward a solution of the problem. He takes the different classes of construction and assumes that a brick wall of a certain thickness or a stone wall of a certain thickness will absorb so many heat units per unit. He assumes the loss through glass surface as so many heat units per hour. He also assumes the change of air in the room to be so many changes per hour and so many heat units per cubic foot of air. He works it down to the square feet of radiating surface, from that to pounds of steam condensed, and from that to the power of the boiler. A similar table was afterwards brought out in an engineering paper of which I happened to pick up a stray copy. I do not even know the name of the paper. It was some six or seven years ago that I picked it up. But the table was shown and an example worked out of the results obtained from it. I was very much interested in it. At that time I had a contract for heating a large mill with a saw tooth roof cut up into skylights. That building was 250 feet square. It was two stories high, the looms being on the second floor. It is very difficult to heat a building 250 feet wide, especially with a roof of that kind. In the first place I took the plans of the building and worked it out in my regular way. I laid all the papers aside. I then took and worked out this rule in that same building, and when I worked out the rule I was satisfied that it was approximately correct. I went

ahead and heated the building on the rule and took my chances on it. I was figuring on the use of exhaust steam supplemented with live steam through a reducing valve at one or two pounds pressure. I have never had any trouble with it. Now here is a definite form that all of us can get at. When we have a set of plans we can easily find out the thickness of the walls. We can ask the architect as to the manner of construction if we want any further information than the plans give us. We can measure the outside wall exposure and the glass surface, and if the building is not going to be ventilated by any fixed system we can assume that the changes will be, say, three changes per hour as a maximum. Working that down to the basis of units of heat we can very readily determine our heating surface. Having the heating surface with the rules I gave here yesterday, you can determine the size of the mains and you can get back to your condensation, if your building is going to be heated and not have any power in. As a rule, in large buildings we have more power than we need for heating, because the machinery of the modern building is so complicated and requires so much power that, generally speaking, you have nearly as much exhaust as you want. In fact, in some buildings I have more exhaust steam than I need to heat the building with. I have not worked out the formula in this paper at all, but the other that I give applies to the three conditions, the exposed wall, the exposed glass, and the change of air. This makes no reference to the change of air. That is an important consideration, as well as the loss through walls and windows.

Mr. Quay :—There is a question that we have found a good deal of difficulty in determining, and that is in large conservatories, which have a very large glass surface and are often not very tight, we find it is harder to get definite information from experience and data in regard to this class of heating. There is also the question of ventilation that I would like to hear discussed a little, and that is in regard to the ventilation of hospitals for contagious diseases, on the question of burning the foul air. I do not know whether anyone has had any experience in that line or not, but it is a question that is going to come to the front, I think, very soon. It is pretty hard to get any data in regard to the amount of surface required and what is the best way to dispose of the air so that the disease germs will be destroyed, and in that way avoid the annoyance of having hospitals in the cities where the people are exposed to that kind of air.

Mr. Jellett :—The rule that I have just outlined as to the loss in units per square foot of glass surface would answer Mr. Quay's

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question about the greenhouse, because the ratio is very much higher to the glass than it is to the wall.

Mr. Smith :—While perhaps it is not very good taste for a member of the society to say that there is such a thing as running too much into heat units and from heat units into somewhere, so that there is a standing inquiry in one's mind as to where he is at, yet I believe a great mistake is often made by sticking too close to data and formulæ, and too little to observation that we get in our experience. A little while ago I had a case where data on a 6-room school were required. An engineer was appealed to to act as a sort of umpire, although it was between two other engineers. They differed, and this man was selected as a sort of umpire. He was a man of very high standing, but a man who could not heat a 6 by 10 room without first of all figuring about four pages of formulæ about the walls and glass and key-holes. The question he was asked was this: Given a 6 room school, under the laws of Massachusetts, how much heating surface do we need to warm the room by direct radiation? How much do you need to warm 100,000 cubic feet of air from zero to 70 degrees? What boiler power do you need to carry this heating surface? He started with the loss per square foot of glass surface—that was so much. The loss per square foot of wall surface was so much. But in his data he had to guess at a few features, and he finally figured out the amount of direct surface necessary to overcome in zero weather that cooling effect of walls and windows. Then he made a good liberal guess for winds and a good allowance for other things that he had not thought of. A matter of that kind has never been figured out by an engineer in heating and ventilation who did not assume one element of the formula. In this particular case he assumed the number of heat units going to be lost per square foot of surface per hour. The only difference between the result that he got and the result that I got was that he assumed a different number from mine. But after he had gotten through he had about six pages of matter which was very nice. No paper has been presented here that shows anything like the amount of thought and attention that that showed. But it figured out 700 and some odd square feet of surface of the six rooms. Then he figured up the number of heat units and he had that just right. Then he divided for the direct radiation. He divided his total number of heat units required by 250, that being the number of heat units given out by a square foot of surface. Why did he divide it by 250? Why didn't he divide by 150 or 400? That is the element that he assumed, but in that case he assumed the same as I did and we

came out the same together. In figuring out the heat units we differed. He had gotten a different specific heat for air than what I had got. But that did not make any difference. But when it came down to the question of the intake, then the factor that he divided by was 400 instead of 250. The starting point of this proposition is this, that the loss by contact alone was 150 feet more than by contact and radiation combined. I had divided by 1,200. He said it would only use 400. The result was that he wanted about three times as much heating surface as I did. There was no flaw in his data so far. We come now to the next point. You know a man can get so engrossed in his problem as not to think of the result at all. Suppose we heat the building entirely by indirect radiation, then how much surface do we need? What was the result? He said that where he needed 740 feet by direct radiation we would do the same with 420 with indirect. Nobody in this room would atempt to heat a room with less surface by indirect than he would by direct. Nobody here would make the statement that the loss by contact and radiation would be less than the loss by contact alone. The man had figured, and figured so long, that when he came down to that last proposition he had made himself do as much with 400 feet of surface placed down there in that manner as he could with 700 feet of surface placed in the rooms. Here is a case where he figured altogether too high. The question was brought up here as to how much heating surface was necessary to heat greenhouses. We have got to take in not only the data as to the amount of glass surface exposed, but the question of construction. The practical side of this is, how much surface must I allow when I am figuring on heating somebody's greenhouse and that somebody is a man who will build his greenhouse cheaper than somebody else? I am making a contract to heat that to 70 degrees in zero weather. You may take all the formulæ that they have given and unless you go in and make some kind of a liberal guess the data are simply guide-boards that point in a certain direction. You have got to know something about the country in order to travel through, and so, while these formulæ and data are excellent things as starting points, they are mighty poor horses to ride.

Mr. Barron :—A great many here have had practical experience of the conditions that Prof. Kinealy has tried to meet in this paper. Would it be agreeable for some of those here to relate their experience, and how they overcame it, and what their idea is of the value of Prof. Kinealy's method of treating it? It seems to me that if you went to the average architect, and generally he would be

there with the owner, and told him that there was a certain rule for testing your apparatus and all you had to do was to close your rooms and get steam and you could figure that out for him and satisfy him that the building would be satisfactorily heated in cold weather, and he should pay you the last payment, I think most owners would say they did not understand anything about that, and want to know your authority and all that sort of thing, and the architect, I think, would agree with the owner, and I think he would be wise in agreeing with the owner. I do not think you could establish a rule that would work practically. The best thing you can do, if they insist on a test in hot weather, which I believe this is really intended to meet, the best thing is to give them a little lecture in elementary physics, show them how difficult it is to get high temperatures as temperatures approach, and all that sort of thing. I think if you attempted to go to them with this mathematical matter, you would not have any success at all. This, I think, is advisable from our point of view. It is advisable to discuss it. But to get a practical working rule it would have to be far less complex than Prof. Kinealy's rule.

Mr. Harding :—My experience has been that there is no method by which you can absolutely prove what the performance of a heating plant will be until you actually have that performance under the condition under which you guaranteed it. The best settlement is, if the customer is not willing to pay the amount that is due, to make an agreement with him to pay six per cent interest on the money until he gets ready to pay it. That has always been my way of settling it.

Mr. Smith :—If some customers I had two years ago had made that agreement I would have been drawing a good deal of interest by this time.

Mr. Jellett :—I was going to say we would all be bankers by this time.

Mr. Baldwin :—I heard a gentleman say something about warming a building—that less surface would do for indirect radiation than direct. I have had experience where actually less surface was sufficient for the indirect than for a direct job, but it was where the draft was exceedingly good. Indirect surface will give off heat in a measure proportional to the amount of air that comes in contact with it, and I have a case in practice where it was necessary to use 100 square feet, where 60 was sufficient to warm it, so that the heat given off, of course, depends on the rapidity with which the air comes in contact with the surface and passes away from it.

Mr. Smith :—In the first place, understand that here is the condition of the 6-room school—an unmingled system of ventilation, and the only flow of air we get is due to the loss of heat from the heating surface itself. We have in the basement beneath the floor the stack of indirect surface and the flue. Just above that is a direct radiator free to give off heat by contact with the flue almost as great. It is four feet high. Under these conditions it is absurd to say that by indirect radiation we can do nearly double the warming per square foot of surface than by direct. But the point I made is the fact that this engineer assumes 400 heat units per square foot of surface as the loss for indirect radiation and I use 1,200. If you will take a 6-room schoolhouse that is heated by the ordinary hot blast system, you will find that instead of dividing by 400 or by 1,200 that they more nearly divide by 2,000. For instance, almost any firm will take a 10-room building and agree to heat it with a dozen square feet of heating surface in their heater, whereas under this rule they would have to have over 3,000 feet of heating surface. So I said to the architect, "You know yourself that this is an absurdity." I showed to him right away the absurdity of assuming 400 instead of 1,200 or something else. If you have got to assume one factor in a formula, why not use your guesser and assume the whole of it? It takes as good an engineer to settle what that one factor shall be as to settle what they all shall be. So I say experience, wide observation, practical experience above all things, is better than all the data that ever was gotten up, and I say that the giving out of formulæ to the average engineer,—placing myself with the average engineers—obliges us to go back and look at our books before we can determine the formula at all. It is an awfully easy thing for me to say you have to figure out that T is equal to the square root of PDQ, but the steam fitter cannot sit down and figure it that way.

Mr. Quay :—The reason I spoke of these questions is that we are probably liable to talk from the contractor's standpoint a little more than from the engineer's. Are we allowed that privilege, Mr. Chairman? This very point of the different formulæ that we have in regard to figuring radiation of glass surface and wall surface—we get all those things defined and we are very glad of them. We do not wish to say anything against the engineer or these men who write books on these questions and give us these formulæ, because they are very useful. We find though, sometimes, that we have to heat a building where we have a velocity of air outside of 60 miles an hour. We find other times that the building is isolated and very much exposed. Another time

we heat a building that is set close to another building that is heated. Now, you can take this formula and figure on that basis and you will get left. If you undertake to heat a building that is isolated and exposed to a direct current of air, sometimes at a velocity of sixty miles an hour, using the same formulæ and the same data that you do for heating a building that is not isolated in that way, you will get left. Then we have the question of the kind of radiation we are going to use. It has been stated that some radiation is more efficient than others. We find that the air comes in along the windows and places of that kind that we have to guess at instead of figuring, and especially in heating conservatories, if they are very large, we cannot stick to data exactly ; we have to make a certain allowance for this glass not always being tight, so that if we stick to data alone I will almost guarantee that we will in some cases, at least, get left.

Mr. Baldwin :—A beginner in any science must have some data to start from. The data may be only close approximations to the truth, but it is a good thing to have a close approximation to start on. In all engineering it is necessary to have some factor to commence with and then a factor for safety. These rules are, as a general thing, a close approximation to the truth, below which you must not go and above which it is necessary to do all you can afford. So that while practice is necessary for success, data is necessary for commencement.

Mr. Smith :—I agree very thoroughly with the position taken by the paper, but there still comes up this point again—who is the beginner, the man who starts in from selling books or the man who grows up under an employer ? Has he not gotten data ? Doesn't he know how much surface his employer has been using under different conditions ? Taking the statement of Mr. Baldwin that data are points below which you must not go, the data that are nearly always given by these engineers are the points above which under no circumstances you ought ever to attempt to get. Take the engineers and let them lay out plans and specifications, and where you put one foot of surface you find two called for. Where you have been doing the work with ten horse-power you find 20 specified. No specifications are so expensive as those which are figured by the engineers who rely on the formulæ, and you very seldom go to the specifications of such engineers but that you are certain you can get out sometimes 50 per cent of the power specified and get your results all right. So that I say the data generally given are not the points below which you must not go, but are nearly always at the top. When our business takes

such a position that we can be treated as engineers and get the pay of engineers, then we will come around to these other real nice things, but that is not the position at present. The engineer finds himself confronted by a fan-selling firm who offer to draw plans and specifications for nothing. He finds himself confronted with the man who sells boilers and who has his specifications struck off by the printing press. That is the condition of things we are in to-day. I say that when we level this up to where we want it, when we can treat this from the technical engineering standpoint, then we will come down to this nice stratum of data, and then we won't do anything but figure, which is a great deal easier than going around the jobs and finding out where you make mistakes.

The Chairman :—I would like to say that the discussion is on the determining of the heating power of heating systems.

Mr. Hopkins :—This discussion on the value of data and so on called to my mind a problem that our friend Mr. Wilson submitted to me last night, in a spirit of mirth, I suppose, and I think you can see, after hearing the different opinions expressed, that there is some chance of making a connection between the two. He asked me : "If there are 13 seeds in a small pumpkin, how many are there in a big one ?" They start in with data upon one building and try to apply it to all. It is a good deal as Mr. Smith has said. The actual experience, the judgment, the guess, is worth about as much as the figured out formula. Major Light has had a good deal of experience about the country on these various points. I think he could give us some considerable information in regard to them.

Major Light :—In my experience of 23 years in various states and latitudes I have learned one thing very positively, and that is that it is strictly a matter of good sense founded on an extended practical experience, and I do not know of any other school in this matter that I would wish to attach my fortunes to as a contractor working for certain success and for certain pay.

Mr. Jellett :—I have been very much interested in Mr. Smith's remarks, which directly back up the position I took yesterday on the matter of paying for plans, etc., which I think is really the proper solution of this question. I do not think any of us would be asked to bid at random in competition. The usual clause that is put in a specification that the system can be guaranteed to heat to 70 degrees in zero weather has been the bone of contention. The owner assumes to know nothing about what he is buying. His architect, as a rule, does not go any further. He says the

contractor will guarantee his work and there is no use going into the details. The guarantee is that the building will be heated to 70 degrees in zero weather. There is no assumption as to when we are going to have zero weather. As a matter of fact, in Philadelphia, up to the winter of 1893, we did not have zero weather for 11 years, so if we had been caught in such a position as that we would have been in a bad way. I never sign a contract that has that clause in it, nor would I sign a contract that had the provision that the work must be satisfactory to the owner or to the architect. I cannot figure for that and therefore I will not sign a contract which contains that clause. I have been called in to pass on matters in dispute between other contractors. A gentleman a short time ago asked my opinion on a case. The system, he said, was guaranteed to heat to 70 degrees in zero weather. I went over the system carefully. I found that it was a very large building—a church building. He was one of the building committee. I found that they started their fires up on Saturday and that during most of the week there was no fire at all. I asked him if he considered that a fair way to test the heating system. He said, "It is guaranteed to 70 degrees." I said, "Do you, in your own house, put your fire out and go to bed and expect to have your house at 70 degrees in the morning?" He said, "No, I do not." I said, "What right have you to put the fire out six days in the week and expect to warm this great mass of space within a few hours? You would have to put enough boilers and radiators in to have a drying room under ordinary conditions." Now the owner, of course, expects some ground to stand on, as he knows nothing about what he is buying, and the clause I put in is that the system is equal to maintaining a temperature of 70 degrees. I have some ground to stand on then, because I can maintain a continuous service of 70 degrees with very much less heating surface than I can create a temperature within a fixed time determined by the owner's idea of what he wants. My experience is that even with a well designed system in a building of average exposure you cannot gain more than six to seven degrees per hour in temperature. It is entirely at the option of the owner as to when he expects that 70 degrees under the guarantee clause generally used.

Mr. Smith :—Upon the question of the guarantee to be made, my formula has always been about this—that the system and apparatus shall be capable of warming the building to 70 or 72 degrees in any weather prior to a given date in a certain year. They take the chances on what the weather is going to be. We are starting a school house now that is going to be finished next fall. We say

in our contract that the system and apparatus shall be capable of maintaining this temperature in the coldest weather prior to March 1st, of the year following. That is a guarantee that protects both sides. The guarantee that we used to get in the catalagoue that some of the steam blast people put out, to warm a building to an average temperature of 70 degrees in any weather, that is the kind of a guarantee that some of the hot blast people would like to make when the air could not get to one side of the building because the wind was blowing on the other.

Upon the question of ventilation the guarantee should be something like this—that a certain supply per person, per minute or hour, shall be furnished, or it should be that the air within the room shall have a certain standard of purity, that standard of purity being determined by air analysis, this air analysis being made with testers that are simple things and that anybody can run. Heating engineers would do quite as well to test with the Wolpert air-testers as with the anemometer, because committees have as much respect for that as for the anemometer, as they do not know anything about either. The Wolpert tester is one of the best things ever used. If you want the system to succeed all right you squeeze out all the air there is in the bulb and you put in a little more lime water and it takes a little more, and you can get results the other way by reversing the process. These are tests that used to be made under the department in Massachusetts, before we learned to use the apparatus. So, in this making of guarantees, one of the first functions of this society should be to name a committee who shall agree upon a certain set of plans and that then, when contracts are made, these plans shall be taken as the standard of this society, precisely as the architects and builders have a builder's contract which is agreed upon by them. You can say to your customer, this is the guarantee that has been adopted by this society. It is perfectly fair to all parties and it will save a great deal of difficulty.

Mr. Barron :—I would like to say a few words if I may be allowed a little latitude. I cannot bind myself to talk closely to the title of this paper. But I think that what I say will apply to it and also to Mr. Smith's and Mr. Jellett's remarks. I wish to say that my experience agrees with nearly everything Mr. Smith said about the coefficient of common sense, judment, and all that being superior to all formulæ, to all data that have been discovered. I realize the fact that there are two ways of doing everything. You can tell the time by the sun, as Emerson points out. But man has learned to tell the time by a watch and forgets how to tell it

by the sun. I consider that my experience and judgment are far superior to formulæ, although I realize that the man of formula is the coming man. It is simply a change of method. We guarantee to heat a building to 70 degrees in zero weather. We always try to do it and we always try to collect our money before zero weather. I think the difficulty is really more imaginary than real, if you consider the vast mass of business that has been done in heating houses. I do not proportion radiating surface by any data or any formula, except the coefficient of common sense and judgment of experience. We know what radiators we have been putting in a certain class of buildings for years and we lay out certain radiators for certain rooms. Of course we know these radiators bear a certain proportion to the exposed walls and windows and all that sort of thing, but we lay the radiators and a good deal of work without any rules at all. Of course we figure the cubic contents and we do not have many difficulties. I have never had but one case where I was confronted with this difficulty which Prof. Kinealy treats of in this paper. That was about eight years ago. We had a block of buildings and the architect wanted to be satisfied before he gave us a certificate for the last payment. It was in August and very hot. I took him up there and we spent the whole afternoon testing the apparatus. I reasoned with him, as I said before, on the great difference of heating a building in summer and winter, and he finally gave me a certificate.

Mr. Baldwin :—The coefficient of common sense in the case of the new Pension Office brought forth some peculiar results. One contractor wanted to use 84,000 feet of surface. The Walworth Manufacturing Company used 24,000 and got the contract and warmed the building. The quantity of surface proposed by the different contractors ranged from 24,000 to 84,000 square feet. I think that the Walworth people, in making their estimate, were helped by taking the outside of the buildnig, and they had to look out for the skylights. But there a little data founded on facts and condensation and cooling surfaces got them the job.

Mr. Barron :—I hope Mr. Baldwin will pardon me for saying that I think the Walworth Manufacturing Company's coefficient of common sense was a very good one, and I think they used it there in connection with the data.

Mr. Baldwin :—But you realize that the cubic contents of the building had nothing to do with the amount of surface that went into it. The new Pension Building is a great barracks, as it is called, around which are a number of rooms, with a great open

space in the center that goes to the roof. Now, taking the cubic contents and taking 1 to 100, it would call for 50,000 feet of heating surface. But, as a matter of fact, taking the outside surface of the building, taking the glass and the walls, 24,000 feet warmed it. That is the point I wanted to bring out.

I remember in old times I worked for Blake & Higgins, 30 years ago in New York, and I said to Mr. Blake at one time, "How do you figure radiating surface?" "Oh," he said, "you are too young in the business yet." I thought at that time that Mr. Blake knew something that he did not want to tell me. One day shortly afterward I was going around with him and he said, "Baldwin, put a 40 in that room, and a 60 in this room, and an 80 in that room." And when we finished there was about 40,000 feet in the building. He said, "We will use boilers 48 inches in diameter and 12 feet long." I said, "How do you get at the size of the boiler?" He rather smiled, and thought I had better wait a little while. Well, there is a great deal of that to-day. (Laughter.)

Mr. Smith :—Occasionally I get a new man who wants to know how to figure out the heating surface to be used. That is a question that staggers me every time, and I have always been obliged to plead to the fact that I was too busy just then. I have to lay out my work in just the same manner Mr. Blake did 30 years ago, by simply putting down so much here and so much there. The Walworth people had learned that cubic contents had nothing to do with the case mentioned by Mr. Baldwin, and that is a very valuable point for many young engineers to learn. For instance, you take a room that is 20 by 40 and you get your 800 square feet of floor surface. Multiply 40 by 40 and you have got 1,600 feet, and you have doubled the cubic contents and you have increased your wall surface only about 20 feet on each surface, so that the proportion of heating surface would not run up in any such manner. It is wall surface that has to do with it. But I would like the man of figures to point out to Walworth any set of formulae by which that data alone, and without any element of common sense, they would have got down to that basis of 24,000 feet. I am quite willing to believe that the other man got his data from somebody's rules.

Mr. Quay :—I think that the contractor who lays aside all data and places a radiator where he sees fit is just about as far off as the engineer who follows data entirely. I think there is no reason why the engineer should not have this common sense that is talked about. I actually believe that the contractor or any one who is laying out heating apparatus needs data as well as anybody else. We

use all we can get of it, and would be very glad to get more. We use our experience too. I think you have got to combine the two very closely.

Major Light :—I was going to remark that it has always seemed to me unjust that plans and specifications in detail should be prepared by some architect or other person asking for bids and that then the person bidding should be required to guarantee the effectiveness of the apparatus or the life of it. That is very commonly done and it is very unjust. I know of a contract let this present year where everything was specified, the kind of valves, the air vents, the radiation, boiler setting, trimmings, everything that made that job. Yet the party was required to guarantee the effectiveness of the system in zero weather and to guarantee the apparatus for three years for succesful operation. That specification was made by a Detroit architect. There needs to be a limit somewhere, and possibly it is in the province of this association to determine the limit, if not immediately, a little later on. I merely mention it that we may think more of that matter.

Mr. Baldwin :—On the face of it, it is a confession that the engineer does not know what he is about. It is probably known to a few here that the bulletin for next month of the Master Steam Fitters' Association will contain a rough draft of general specifications for steam heating. It is sent out, I believe, for criticism, so that the gentlemen here will have an opportunity to offer suggestions. The question that Major Light suggested can be looked into and other questions suggested. Certainly when a man defines the amount of surface and how it is to be disposed, he ought not to ask for any other guarantee. But it is the custom, and on the face of it, it is a confession of ignorance on the part of the man who draws the specifications.

Major Light :—Some law suits have been instituted in connection with contracts of that kind. I do not know that the law is the same in all states, but it has clearly been settled in some of the states that when specifications and plans complete in detail are given out for bids, and a person bids on those specifications and sets up an apparatus consistent with them, that is the contract, and liability ceases, and I think that was a righteous decision.

Mr. Jellett :—I think that this society could get up a form of specification and a form of contract in line with that of the National Association of Builders. I am a member of the National Association of Builders through the Philadelphia Master Builders' Exchange. The questions they have to deal with affect all classes of contracts on buildings. The local associations and exchanges

have a national association. It is conducted on a broad-gauge plan, and all matters of any kind affecting the interests of the members as individuals, or in different sections of the country, are taken up and discussed. Some two years ago a committee was appointed by that association and one was appointed by the Institute of Architects. These two committees came together and agreed on a definite form of contract which would be fair to the owner and fair to the contractor, and which would give to each his proper rights. That contract is being generally introduced. It is being pushed by the Builders' Association and by the Institute of Architects. It is furnished in quantities by both associations. That contract has given very general satisfaction. I have in my hand now a bulletin published by the National Association of Builders once a month, and they take up and discuss in a broad way the general questions as to unfair requirements and things of that kind. They take specifications that are sent to them for criticism, and they outline them in such a way as to show the members their rights under that particular contract. I will mention a case that occurred in Philadelphia in respect to elevators. There was a clause in the contract that the elevators should run in a manner entirely satisfactory, but there was no statement as to whose satisfaction was referred to. The elevators were put in and started before the building was occupied by the regular tenants. As soon as they began to move in the elevators received very hard service. Being new and not having the proper attention as yet, they gave some trouble. The owner was a very hot-headed man, and he telegraphed to the elevator company to have those elevators in proper working shape in twenty-four hours or he would tear them out. They did not get their men there within the twenty-four hours, and in accordance with his telegram the owner had the elevators torn out the next day and thrown in the back street. The elevator company sued the owner. The matter came up in the local court in Philadelphia, and judgment was given for the owner. The judge read the clause in the contract that the elevators should be entirely satisfactory. He said, "Who are they to be satisfactory to? Certainly the other party to the contract, because this same word is used in the proposition of the builders of the elevators. Now, the other party says he is not satisfied; that is the end of it. The advice of the court would be to the contractor not to sign any such contract. If a man is foolish enough to enter into such an agreement he must abide by the contract." The matter was then appealed to the new Court of Appeals, and the owner was beaten. He told me that he was beaten, and that he was properly beaten. He said, "They proved that I was mad

that day, and I did not use proper common sense in determining that matter and did not give them proper time to do it. I believe that I cut the thing too short and I paid the bill." But they had to fight for four years to get it. The equity of the thing was decided in that case. Now, in any agreement of that kind, equity must underlie the whole matter or the contract will not stand. It may stand once or twice, or it may bear very hard in certain localities, but the best means of curing such a case is to enforce such a requirement. We can get up a form of specification as to the general conditions governing the matter and leave the details—sizes of boilers, radiators, etc., blank, to be filled in, and we can make those general conditions fair to both parties. It can be a dignified specification, and there should be a dignified contract that is entirely legal, without being too long or too complicated. We would fill it up in carrying out the agreement later on. Such a contract the builders have, and all who have used it are satisfied with it. Some few of the architects still adhere to their own particular forms, but they are gradually changing. I know of one who had some three years ago the most arbitrary specifications I ever saw. While I act as his consulting engineer I would positively refuse to sign his contract. He has to-day a very much better form.

Major Light :—I wish to urge the advisability of the plan proposed, as I think it would tend very materially to the protection of our business. I have always noticed that it is usually the greenest man who will assume the greatest risk, and while many experienced men will refuse to sign such contracts, I have found that plenty of others are ready to sign them and take all those risks. They are green, but the builder or owner will finally let them the job. I think if we can carry a measure of this kind and have it adopted it will tend to keep these other fellows out.

Mr. Smith :—I think there is a large class of architects and some builders who realize that there are always a certain number of new men who are seeking experience, and they draw the specifications with the idea of giving these people the experience they are after. They know that reputable builders will not sign such specifications. They also know that there are some who are seeking experience and are ready and willing to pay for it. We should in every way discourage the idea of assuming the responsiblity for the work of others. If an architect is not willing to assume responsibility let him pay us for planning. That should be the practice of every engineer and of every man in the heating business.

IV.

HEATING AND VENTILATION OF SCHOOL BUILDINGS

BY T. J. WATERS, CHICAGO, ILL.

(Member of the Society.)

The subject of heating and ventilation of school buildings is one which has been ably discussed from various standpoints by eminent heating and ventilating engineers for a number of years, and in view of this fact it is with a great deal of diffidence that I make the effort to address myself to the subject. It may safely be stated without fear of contradiction that a system of steam heating and mechanical ventilation, properly arranged and proportioned, is the one recognized as being superior to all others by the most advanced heating and ventilating engineers of the present time. A brief history, therefore, of the introduction of the first steam heating and mechanical ventilating apparatus in a Chicago public school may not be out of place, but rather of interest to the members of The American Society of Heating and Ventilating Engineers.

The building referred to is the Dore school, located on Harrison street, near Halstead street. This structure is of brick, four stories high, and contains 16 class rooms, one office, and two recitation rooms. It was erected in 1867, but the system of heating and ventilation was not finally determined upon until the building was nearly completed. The original intention was to heat by furnaces, but owing to the indefatigable efforts of Mr. W. J. Twohig, now with the Crane Company, but at that time of the firm of Walworth, Twohig & Furse, then leading steam heating contractors in the West, the Board of Education decided to take a step in advance of the times and accepted the proposition of said firm, which provided for a system of indirect steam heating and mechanical ventilating apparatus, designed and installed under the direction and supervision of Mr. John Woodman, its superintendent. The apparatus consisted of two horizontal tubular boilers 42 inches by 12 feet ; with thirty-four 3-inch tubes each ; four return bend coils of 1-inch pipe, each 22 feet long, 14 pipes high, by 12 pipes wide. These coils were located in the basement corridor and inclosed in brick work. Each coil was connected with four rooms by means

of two tin ducts which extended up in wardrobes and terminated in each room 12 inches above the floor, about 20 feet apart, with a deflecting hood arranged so that the current of air was directed downward. These hoods were also used to control the volume of air, as no switch damper was provided to regulate the temperature thereof. The corridors were also heated from these coils, there being four registers on the first floor. There were four 18-inch steam traps, "pot" pattern, one for each coil, which discharged the water of condensation into a receiving tank, and from thence it was pumped into the boilers. The blower, 72 inches in diameter, was inclosed in a brick housing and was operated by a 9 by 14 inch engine. The blower was manufactured by Morris & Tasker Co., of Philadelphia, and is still in use. For a period of seven years the heating apparatus gave fairly good results, when it was found necessary to remove the old coils, owing to the great number of leaks occasioned by rust in the form of "pin" holes. The coils would have lasted much longer, no doubt, had they been placed in a perfectly dry basement or kept in constant use.

The present apparatus in this building was designed by the writer, and consists of wrought iron staggered pipe radiators, one being placed at the base of each duct. In addition to these radiators, wall coils were placed in class rooms around the exposed walls under windows. The old boilers proved to be inadequate, and a few years after the coils were removed new boilers were substituted. A number of school buildings were heated in the manner just described three years prior to the removal of the old apparatus, and, in fact, all the school buildings heated by steam, up to 1889, were heated practically the same way. Since the installation of the first apparatus various improvements have been made, principally in the manner of introducing air and also in the placing of switch dampers in blast ducts, thus enabling the teacher to regulate the temperature of the air without decreasing its volume. We have several buildings in which disk fans are used, one being a blast fan to distribute air, through galvanized iron ducts suspended from the ceiling, to the various indirect cast-iron radiators, and from thence to class rooms by means of verticcal ducts. The exit ducts from class rooms in these buildings are usually concentrated in a room in the basement, where an exhaust fan is placed to draw the air from the various rooms and expel it from the building. About three years ago the writer discontinued the use of the latter fan for all new work. After a series of careful experiments and observations in old buildings formerly heated by furnaces and subsequently equipped with steam heating and mechanical ventilating apparatus, blowers

being used, it was found that satisfactory ventilation was obtained by the use of the old exit ducts which led from each class room didectly through the roof. There can be no doubt but what a more positive movement of air may be obtained by the employment of an exhaust fan, but the objection to its use, however, aside from the additional cost, lies in the fact that it has a tendency to create a partial vacuum in a room, thus allowing the cold air to rush in through openings around the windows. The warm air entering the room through the blast duct is also liable to be drawn too rapidly to the point of exit, thus subjecting the occupants to disagreeable draughts.

The question of draughts has been a source of annoyance to the writer for a number of years, more especially in buildings where mechanical ventilation is employed. Five years ago I determined to experiment on a new line in an old building which was being remodeled. The building is brick, three stories high, and contains 12 class rooms, an office, and two recitation rooms. It was formerly heated by wall-coils and a system of direct-indirect staggered pipe radiators, two radiators in each room, valved so that either one or both might be used. The radiators referred to were 4 pipes wide by 28 long by 34 inches high. It occurred to the writer that by placing one-third of the total amount of surface, 8 radiators, between the outside air and the inlet to the blower, 72 by 42 inches, the air, after passing through these radiators, would be about 70 degrees, consequently it may be readily seen that a change from the maximum, about 120 degrees to the standard minimum of 70 degrees would be a decided improvement on the old method of using the air for tempering purposes at the temperature of the outside atmosphere. The balance of the radiators, 16, were placed on a suitable platform of wood in front of the blower outlet, arranged in three sections, two radiators wide by two high, and each section controlled by valves, so that any one or all might be used, as occasion required. The wall coils were allowed to remain but are not used except in extremely cold weather, and then only in the morning until the building is properly heated. The blower is operated by an 8 by 12 inch horizontal slide valve engine. The exhaust steam is utilized in the heating apparatus, and cross-connected in such a manner that it may be turned into radiators in the cold air chamber and also in the warm air distributing chamber, or to the 3-inch wrought iron vapor pipe from a cast iron catch basin, which extends up through the brick smoke stack to a point three feet above it. A pressure regulator is used on the heating main, and a pressure of from 1 to 5 pounds

per square inch on the system is sufficient in the coldest weather to maintain a circulation in the radiators. The water of condensation is returned to a sealed tank made to withstand a pressure of 100 pounds per square inch. A water regulator is attached to the tank and connected with the city main to maintain a uniform water line. A duplex steam pump, 5¼ by 3½ by 5 inches, is used to force the water of condensation from the tank into the boilers. The steam heating apparatus proper is known to the trade as Waters' semi-gravity system, and was introduced to supplant steam traps seven years ago.

Since the introduction of the above system a saving of from 15 to 20 per cent in fuel has been accomplished in some buildings from which the steam traps were removed.

The platforms in the cold air chamber, and also in the warm air distributing chamber, stand about 3 feet 6 inches above the basement floor, the space beneath the platform being used as a chamber for the tempered air. The entire chamber is enclosed in brick work, and a galvanized iron duct, 18 by 20 inches, leads therefrom on the basement ceiling, which connects with a vertical duct to each class room. These ducts have openings near the ceiling inside of the warm air chamber, in which a switch damper is located to regulate the temperature of the air passing through them. The ends of the ducts terminate at the bottom of the platform, full size, to receive the air at the minimum temperature. The dampers are operated automatically by the Johnson electric system of heat regulation. A damper is also placed in each duct to regulate the volume of air. It will thus be seen that when one of the switch dampers is closed against the air at the maximum temperature its volume through the duct is not diminished, and also the amount thus shut off from the top of the platform is exerted on all ducts open to its influence. The results obtained from this arrangement were so satisfactory that all new school buildings erected in the city of Chicago since 1889 have been provided with a heating and ventilating apparatus of this character. It is true that several minor changes have been made from time to time, with a view to reach a higher standard of perfection, but the essential features, as above described, still prevail. The style of radiator adopted for this work is 1-inch staggered pipe, 4 pipes wide, 32 pipes long, by 6 feet high.

In designing an apparatus of this kind, care should be exercised in the location of blast and exit ducts. My practice for several years has been to introduce the incoming air toward the ceiling at a point about 7 feet from the floor line and to locate the exit ducts,

whenever practicable, on the same side of the room as the former ducts. The size of each of these ducts will average 18 by 20 inches, or a cross-sectional area of 2.5 square feet.

It is obvious that an amount of air sufficient to properly ventilate an ordinary class room, 25 by 32 by 14 feet, containing 60 pupils, must pass through a duct of the size given above at a velocity of 12 feet per second or 720 feet per minute to furnish the required amount per capita.

Notwithstanding the fact that the minimum temperature of the air has been raised to a standard of 70 degrees, draughts are, in some instances, perceptible to a disagreeable extent if the switch damper is closed against the air of maximum temperature when it is introduced at such a high velocity. Various devices have been introduced by the writer in the shape of deflectors placed in front of the outlet of blast ducts in rooms to break up the current of air, but nothing approaching satisfactory results was obtained until quite recently. The latest device consists of a galvanized iron hood placed in front of the blast duct, which extends on both sides of the same, and presents a cross-sectional area of 6 square feet. The current of air entering this hood is broken up by placing two diaphragms, one on each side of the center of the duct, with a slight curve to each end of the hood. An open space of 6 inches is also left between the diaphragms, thus dividing the inflow of air into three equal parts and compelling it to pass in as many different directions from the hood, at an angle of 45 degrees toward the ceiling. This device has been in operation since the first of September of the past year, and thus far I have not heard a complaint about draughts. The above arrangement reduces the velocity of the air through the same size duct at its terminus about 58 per cent, which fact is worthy of consideration by any person interested in this class of work. It is quite natural to suppose that a galvanized iron hood of such dimensions would look unsightly, but if properly made and painted a color to harmonize with the wall, it certainly ought not to be considered objectionable by the most fastidious. It has been found from actual experience and observations that 30 cubic feet of air per minute, or 1800 cubic feet per hour, per capita, is necessary in order to secure satisfactory results. The above fact was clearly demonstrated a few years ago in a class room which had a seating capacity of 60 pupils. Owing to the crowded condition of the building, however, 10 additional pupils were placed in this room. After school was in session about one hour it was found necessary to open some of the windows, owing to the vitiated condition of the air. A short time after, an

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additional room was fitted up to relieve the overcrowded one, and as soon as the extra pupils were removed, there was no further difficulty experienced.

For some years past the tendency has been to decrease the number of sittings from 60 to 54. It is good practice, however, to provide a blower which will readily furnish the maximum amount of air required without forcing it to its full capacity, especially if it is placed within the building and under a class room. Engines or blowers operated at high velocities will transmit vibrations to walls and floor joists, which are objectionable. If brick walls are used around blowers, care should be taken not to have them touch the ceiling for the reason just stated. A space of four inches may be left between the ceiling and wall which can be filled in by means of a rubber belt or mineral wool, which will reduce the effect of vibrations to the minimum.

The boys' and girls' closet rooms erected during the past six years are isolated from the main buildings, but are reached by connecting passages from the basement rooms. Said closet rooms are heated by ceiling coils only, no indirect heat being used. The ventilation of these rooms is accomplished by a 36-inch disk fan and combination engine. The fan is located in an inclosed chamber at some central point between the closet rooms. A galvanized iron duct of suitable size is extended from a point near floor line in each room to a fan chamber, and from thence the air is expelled outside of building. Until three years ago it was the practice to heat the said rooms by direct and indirect radiation, but the latter was abandoned because it was found impossible to keep the doors closed leading to the basement rooms. As a result the slight pressure occasioned by the blast from the indirect chamber caused an outflow of air from the closet rooms when the doors were opened, which invariably found its way to the corridors and ultimately to the class rooms. If closet-room doors remain open now, the air moves in the right direction, or just the reverse of its former course whenever the fan is in operation.

During the present year I decided not to specify wall coils for class rooms of new buildings. The only direct heat now being used is in the shape of radiators located in the first and second story corridors. Doors are provided in the cold air chambers, so that air may be taken directly from the building in the morning up to about one-half hour before sessions begin. The exit ducts from the rooms are brought together in the attic and connected to a circular duct which extends through roof, properly capped. In some of the large buildings there are two ducts, as de-

scribed. A damper is placed in the said ducts in such a manner that they may be operated by the engineer by means of a cable which extends to the basement. These dampers are kept closed in the morning, thus avoiding the introduction of cold air through exit ducts. When air is introduced from outside of the building the dampers in the exit ducts are then opened. A building can be heated in this manner at least one hour earlier than it is possible to heat it by taking air directly from outside, which means a considerable saving of coal.

We have about 300 school buildings, including rented buildings to relieve overcrowded districts, in which are used nearly every conceivable style of heating and ventilating apparatus. There are 150 buildings heated by steam, and 75 of these are equipped with a heating and ventilating apparatus similar to that introduced 5 years ago, and which has been fully described above.

It may be of interest to know the cost of a steam heating and mechanical ventilating apparatus since new methods have been adopted, as compared with the old style of 5 years ago, for a building containing 17 class rooms, one office, and two recitation rooms.

	1889.	1894.
Steam heating	$7,595	$3,883
Mechanical Ventilating	6,106	3,400

which shows a saving in cost for both apparatus of about 46 per cent in favor of the present system.

DISCUSSION.

Mr. Barron :—The first part of this paper deals with historical matter, which is very valuable in regard to heating and ventilation in Philadelphia, and he mentions a fan blower made by Morris & Tasker in Philadelphia, which was probably designed by Robert Briggs. I will commence to read after the historical part:

"The present apparatus in this building was designed by the writer, and consists of wrought iron staggered pipe radiators, one being placed at the base of each duct. In addition to these radiators, wall coils were placed in class rooms around the exposed walls under windows.. The old boilers proved to be inadequate and a few years after the coils were removed new boilers were substituted. A number of school buildings were heated in the manner just described three years prior to the removal of the old apparatus, and, in fact, all the school buildings heated by steam, up to 1889, were heated practically the same way. Since the installation of the first apparatus various improvements have been made, princi-

pally in the manner of introducing air and also in the placing of switch dampers in blast ducts, thus enabling the teacher to regulate the temperature of the air without decreasing its volume. We have several buildings in which disk fans are used, one being a blast fan to distribute air through galvanized iron ducts suspended from the ceiling, to the various indirect cast-iron radiators, and from thence to class rooms by means of vertical ducts. The exit ducts from class rooms in these buildings are usually concentrated in a room in the basement, where an exhaust fan is placed to draw the air from the various rooms and expel it from the building. About three years ago the writer discontinued the use of the latter fan for all new work."

Now I wish to start at that point and discuss that feature, because I believe it is a very valuable one. In all the work designed for the New York schools, and a great many other schools, I believe, there are some exhaust fans used as well as the blowers for forcing the air in, and from Mr. Waters' practice in Chicago it seems that the exhaust fan is not necessary, that he gets just as good results without it, and while I have no practical experience whatever in school work of this character, my opinion has always been that the exhausting fan was unnecessary, that as good work can be done by forcing the air in on the plenum system.

I will proceed with the reading: Mr. Barron read from the paper from the end of the preceding extract to the end of the sixth paragraph closing with the words "The style of radiator adopted for this work is 1 inch staggered pipe, 4 pipes wide, 32 pipes long, by 6 feet high," and continued as follows:

I read a description of this school heating of Chicago by Mr. Waters about two years ago and I thought it was rather a crude arrangement. It is ingenious in the design, but the idea of using radiators for a hot blast heater, putting a part in the cold air entering and the other part in the front of the blower semed to me a rather crude arrangement. Mr. Waters starts in and designs an entirely new arrangement of his own by using ingeniously certain makes of radiators made in the West. That kind of work I do not think would be tolerated in the East at all. Then, his water system of gravity return—I believe he brings all his separate returns to his tank. I do not think that would be accepted here. In the East, where they utilize exhaust steam, they use a pump governor and then utilize the exhausts on the system that was fully described by Mr. Bates in a paper read before the Master Steam Fitters' Association several years ago, in which all the exhaust steam from pumps and engines is taken to a tank and distributed to different parts of the building. I think that system is much superior to this system in use in Chicago. I think Mr. Waters makes a

mistake in specifying for his new work this system that he advises. His schools should be designed each one on an individual system and in my opinion he ought to abandon these radiators.

I will proceed to read the balance of it :

"In designing an apparatus of this kind care should be exercised in the location of blast and exit ducts. My practice for several years has been to introduce the incoming air toward the ceiling at a point about seven feet from the floor line and to locate the exit ducts, whenever practicable, on the same side of the room as the former ducts. The size of each of these ducts will average 18 by 20 inches, or a cross sectional area of 2.5 square feet.

"It is obvious that an amount of air sufficient to properly ventilate an ordinary class room, 25 by 32 by 14 feet, containing 60 pupils, must pass through a duct of the size given above at a velocity of 12 feet per second, or 720 feet per minute, to furnish the required amount per capita."

I think this is twice as fast as the usual common designs. It seems to me an exceedingly high velocity for air to pass through the ducts. (Mr. Barron read from the paper from the end of the foregoing extract to the end of the last paragraph but two, closing with the words "which means a considerable saving of coal," and continued) :

I think that is a very bad practice. There has been an evolution in this Chicago system. First, Mr. Waters had the forcing fan to exhaust. Then he dispensed with the exhausting fan. Then he had direct coils in his rooms. He has got rid of the coils. Now he has simply a plenum blast system which I believe is the cheapest and best way of heating a school or any other kind of building in which people are assembled. (Mr. Barron resumed and finished the reading of the paper and continued) :

I wish to say, if you will allow me, that I have heated a number of parochial schools and schools conected with Lutheran churches, and schools connected with Evangelical Institutions, by direct radiation, and it is valuable to know that you could have heated those schools by specifying a ventilating system at the same cost. But my impression is that the people who do this ventilating work at the price given here by Mr. Waters are doing work for nothing for the glory of Mr. Waters. The men who can heat such a school as he describes for $3,400, I will venture to say, in nearly every case lose money.

Mr. B. H. Carpenter :—I have listened with a good deal of interest to the different points given out here on many different papers. This one seems to hit me most directly on the school house question, and I do not want to go back to the coal regions without having had something to say. We have been doing some of this schoo!

house work, and in many points I agree with this paper. We use but the one fan, which Mr. Waers claims is the best; a blower type of fan, introducing about 30 cubic feet of air per child per minute. Our school houses through the eastern parts of the state of Pennsylvania are supposed to be occupied by about 50 scholars, making about 1,500 cubic feet of air per minute. That is the guarantee that we go under after getting our appparatus in running order and making our tests. We then slow down our engine to that point. While we are capable of giving more than that at any time we keep it down, as I say, to 1,500. We endeavor to put in a large fan, a large engine and blower. In one that we recently started, the engine for an 8-room building was an 8 by 10 cylinder, and the pulleys were arranged by running the engine at 112 revolutions. We were enabled to get over 12,000 cubic feet of air in the building. That would be eight rooms at 1,500 per minute. Well, we can get a little more than that, because the halls were also heated. Now the question was brought up as to its being bad practice to revolve the air over night. I do not think that is bad practice. I think it is a saving in fuel, although we are right in the midst of the coal regions and are only paying 90 cents a ton for the fuel we are using, Pocanning coal, and there is an effort on the part of the directors to go further than that and burn the culm, for which, if you burn it, you have to pay ten cents a ton at the pile, and if you have it delivered, it is delivered at about 35 cents a ton. But should you use this same coal for filling in sidewalks or something of that kind, they are glad to give it to you. But the culm has not been used in this school house work. We have, however, used what we call the river coal. Far down the Susquehanna River there is a large amount of coal that flows down through the river, and it is gathered up by people, who sell it down as far as as Harrisburg for 90 cents to $1.40 a ton. It makes very good coal. We have tried a little of that, but we have not been very successful with it. The pea coal is giving the best results so far. Now I have wandered from the point—revolving the air over night. There are no bad results from that, as with the fan we can change all the air throughout the building in ten minutes. By revolving the air over night it simply saves fuel. The janitor generally leaves his engine running until about five o'clock. That is an hour after our school hours. He then opens his windows, and there being a pressure in the room, the particles of dust are driven out through the windows with the foul air which was left in the room from the children, and by five o'clock the rooms are practically clean. In two or three of the buildings we have no direct radiators

at all, but I think it is a good thing to put in a direct radiator in the hall. But in some of the buildings we have no direct radiators. We simply close off all the fresh air entering the building and allow the air to change with the gravity system through the night, without the use of the fan. The janitor starts his engine, and by eight o'clock you can get pure air there. However, they generally start up a little earlier in the morning, probably by 7:30. I am sorry I have not some papers with me that were handed to me by the janitor of one of the buildings. This janitor likes to make tests in his building, and he made a test on the first of January, this year, there being no school on that day. The temperature in Wilkesbarre I think was six degrees below zero, and he gave me tests every half hour up to 10 o'clock. At 10 o'clock he had some of the rooms at 90 degrees. It ran up, I remember, at the ratio of 28 degrees in 30 minutes in two or three of the rooms. He had, of course, at this time, all the hot air off, and introduced no cool or tempered air at all, which shows that the building can be warmed up. By the gravity system the plants are kept from freezing, and the water is also kept from freezing. It probably stands 60 degrees over night. By the fan system no fresh air is blown into the closets. I agree again with Mr. Waters on that point that it is liable to force the foul air out into the rooms, but we arrange it so that the air from the halls or corridors can be brought into the closet rooms and then by putting good ventilators in the closet rooms, introducing a stack near the boiler stack or having a stack heater, it keeps these rooms plenty warm enough from the air from the corridors and other rooms and still makes a very good ventilation. Our practice has been to introduce the air into the rooms at about eight feet from the floor, blowing toward the cold side of the building, having our register or inlet on the warm side of the building and drawing out the air almost directly underneath the heat register. Generally speaking this is done in one vent. I would rather see the vents scattered a little bit along on the inside of the wall. But under the construction of the building it is pretty hard sometimes to do that. We run the foul air vent up into the attic. From the attic the air is taken out. There is no fan to draw the air off from the rooms. It was forced through by the pressure in the rooms. The fan producing a pressure at all times is a very good feature in a room, because the children sitting along the edge of the room near the windows very often would feel a draft otherwise. Very often I have seen school directors blow smoke against a window, and the smoke would be blown out through the cracks

instead of being blown in. Unless you have a very heavy wind you will find that to be the case at all times. We have on top of the vent flues up in the attic a litle trap door, a simple contrivance arranged with cords and pulleys, so that this flap, by means of the janitor, is dropped down over the vent. He does that from the basement. That cuts off the ventilation entirely. We have had no bad results in any way. We have not heard any complaints of foul air being in any of the rooms. I do not know why it should be necessary to burn the larger amount of fuel to keep the system running through the night. If we have school in the building eight hours out of the 24 and run the engine and apparatus only about nine hours during the day, that must be a saving, and we are saving a large amount of fuel.

I notice Mr. Waters says the rooms are being reduced from 60 to 54. In our district they are trying to reduce them from 50 to 40. Our cloak rooms are ventilated ; they are supposed to take the heat from the rooms and from the corridors. By ventilating them the air is drawn into the cloak rooms, drying out the children's clothes as they hang there, which makes a good feature and also makes good air in the room.

We have never used anything in the way of a hood such as is spoken of in this paper, but I imagine it would be a good thing. We have noticed at times, when the heat register is directly opposite the teacher, that when the apparatus is calling for cold or tempered air, the teacher has spoken of feeling a draft, not a draft directly underneath this register, but at the farther end of the room. I suppose the result is the same, if the draft is over the teacher and blows over the scholars, but they never notice it, or do not speak of it. But I should think this hood arrangement would be a very good idea. I would like to hear from some of the parties who have ventilated in different ways.

Mr. Harding :—I had occasion to refer once before in the meeting to points in regard to school house ventilation which I have observed in Massachusetts practice, and also some points that have been given to me recently by the Massachusetts' inspectors of school buildings. In connection with what Mr. Carpenter said about the manner of circulating the air in the rooms, that is solely by the plenum system, without any means of exhausting, he states that it has been found that smoke would go out through the windows. This is in line of argument to show that the air does not return properly to the point of exit. We will assume that the inlet is eight feet from the floor at one end of the room, opposite the exposed side. The air which enters the room and passes along the

ceiling is the purest air in the room. That air descends as it meets the cooling influence of the exposed wall to about the breathing level, and is sent back over the breathing line of the pupils to the exit. Now, if there is an exhaust fan in operation in connection with the fan driving the air, and which shall be speeded at, say, 20 per cent less power than the plenum fan, while it does not create a suction in the room, it directs the air to a given outlet, and has the effect of circulating the purest air in contact with the pupils and draws it out at a given point. Changing the air of a room is one thing, and introducing and discharging a certain quantity is quite another. The opening of the exhaust flues into a common attic or roof space does not create a very strong upward tendency, as it does not possess the elements of a flue or aspirating chimney carried directly to the highest point of the roof and creating a draft within itself to draw the air through the exhaust opening. The value of a natural draft in connection with the plenum system of introducing the air cannot be overestimated, I think. If a fan is not used for the exhaust, working in connection with the plenum fan, there should be some arrangement to secure the draft necessary to properly direct the currents of air.

In the test of a high school building in Massachusetts, the temperature of a room was taken at five places, the four corners of the room and the teacher's desk, and the temperature did not vary more than from 69 to 70½ degrees at the five places at which it was taken. The seating capacity of the room was 74, and the seats, with one or two exceptions, were occupied at the time this test was made. The amount of air being introduced into that room was 5,180 cubic feet, or at the rate of 70 cubic feet per pupil per minute. That was done without any perceptible draft in any portion of the room, and it was done for two hours continuously, no special arrangement being made. The other rooms in the building were heated and ventilated in a similar manner, this being the maximum in any room. Furthermore, that was a gravity system. There were no mechanical means employed in the circulation of the air. I do not introduce this latter fact with any endeavor to prove that the gravity system is as good as a mechanical system, for I do not believe that such is the case. The temperature out of doors that day was, I believe, 28 degrees, and where the gravity system would produce such results with an outdoor temperature as low as that, giving a difference in temperature between the inner and outer air of 42 degrees, and a difference of specific gravity of air consequent on that difference of temperature, in a warmer temperature, of course, the gravity system would fail to bring the circulation up

to that amount of air. I am an advocate of a mechanical means of circulating air through buildings. It is the practice in Massachusetts to connect the various rooms of a building with the cold air chambers in the basement (through which the air is introduced from out doors to the heating apparatus) in such a manner that the janitor may close all of his exhaust openings in the various rooms at the time the school is closed at night, drawing the air through the various rooms and circulating it through the cold air chambers and heating coils, and maintaining the circulation entirely within the building during such hours as school is not in session, there being no vitiation of air by the presence of pupils, and a great economy of fuel being the result.

Mr. Wilson :—I would like to ask Mr. Harding a question. The fact that a plenum is used in a room of course is an indication that there is a certain amount of pressure in the room. Under those circumstances would not the pressure be equalized just as well on the exhaust as on the outside walls of the room and thereby introduce a positive aspiration or exhaust from the rooms ?

Mr. Harding :—I understand that the pressure within any enclosed receptacle is equal on all sides. But in this case the pressure should not be equal on all sides. There should be a tendency greater in one certain direction than in any other, and that direction should be the exhaust opening. For that reason there should be an effect of exhaust and less effect of pressure at that particular point.

Mr. Jellett :—I have constructed practically no work in public schools for the reason that in my section of the country they do not think it is worth anything to ventilate public schools. As the matter stands at present the lowest bidder, without reference to how he is going to do it, usually comes out ahead. I do not go into that kind of a race. I have, however, erected a great deal of work in connection with colleges and institutions of that kind. In the Bryn Mawr College for women I put the blower system in two large buildings. In both buildings I depend entirely on the blower and its heater. The last buildng finished, Pembroke Hall, is some 400 feet long. It stands on top of a hill and has exposure on all sides. The building is used for dormitory purposes, has a large number of bay windows, and there is the maximum amount of glass and exposure. The basement of the building is used only for the heating and ventilating apparatus. The blower is of ample size. My specification limited the blower to a speed of 200 turns per minute, that a specified amount of air should be delivered, not measured in the main pipe but measured in its discharge from

the registers. In making specifications myself I always follow this rule. My plans indicate that there must be so many cubic feet of air coming through each register. The amount of air is measured at the face of the registers. The point raised here a short time ago about vibrations being carried into the buildings leads me to say that in all these different cases I have used steel encased heaters, but I never blow through my heaters from my fan. My experience with blowing through heaters has been that I have trouble with the bearings of my fan, as the air passing over the bearings in cold weather hardens the oil. If there is a great deal of dampness in the air, the dampness is frozen on the blades of the fan in such a way as often to jam it with ice. By drawing through the heater I get a direct delivery into the duct from my fan. My ducts are of galvanized iron. I overcome vibration by means of an accordion joint. It is made of canvas, painted, and the vibrations of the blower are taken up in this accordion joint of canvas. I also introduce a series of dust screens on the inlet of the fan before the air enters the heater and I figure the proportion of these dust screens so as to give my fan its full supply of air. Very many systems I have noted fail from having the dust screens entirely too small. The resistance is very great passing through such a screen and the area must be furnished to offset such resistance. Again, it must be built in such a way that it can be readily cleaned.

Another feature that I have noted in connection with fan systems is the fact that many contractors for this class of work go to the parties who build fans and heaters and say they want to deliver so many feet of air and want a blower and heater that will deliver and heat that volume. Probably the blower maker gives him his standard section of heater and says you want 2,300 feet of pipe for that heater. He makes this up in the number of sections necessary to get in 2,300 feet of pipe without considering the necessary sectional areas needed to supply the blower with air. I find the best blower concerns in this country make very great errors in this direction. I always make a drawing for a heater. I figure the area between the pipes to supply the area of inlet of my fan; I have seen fan blowers in use that have an inlet of 16 square feet and a heater back of it so small that you could not possibly measure in the spaces between the pipes more than six or seven square feet. The result is that the blower can not deliver what it can not get. I know of a system at the present time in which the delivery pipes are well designed. I was asked to examine it. Its failure was entirely due to the fact that the sectional area through the heater would not supply the blower with the air it needs to do

its work. The fan cannot get its air. In the class of buildings that I speak of I have abandoned the use of the exhaust fan and introduced in place of that an aspirating coil for exhaust ventilation. I never discharge into an attic and pass out through louvers. The attic is cold and the louvers are subject to wind pressures. When you discharge a number of flues into a large attic which is cold, you have no control of the air. You cannot positively blow so much of it outside the attic. I have seen attics with a high pitched roof actually stop the ventilation. I gather my flues together in the attic by means of ducts to a central chamber and I put an ample aspirating coil in that and carry a main ventilator through the roof and design it in such a way as to prevent down drafts. My experience has been that exhaust fans placed in an attic are inaccessible to the janitor, or rather he thinks they are, and they are neglected. I have found they run them at all sorts of speed, and I have gone into such buildings and found them standing still because the janitor forgot to go into the attic and start them. The valves for controlling the aspirating coil I always place in the basement beside the fan. My main pipe starts from the basement; my return comes back and both valves are placed there. The results have been very satisfactory. With the pressure from the fan offsetting leakages from windows the aspiration of the coil from the attic taking out less air than the fan is capable of delivering, I get a very uniform temperature and a very uniform delivery of air. Of course all these things depend on a careful study of the use of the building and the number of people who occupy the rooms. It is not a system designed for the ventilation of a public building whose use varies. I have a building in mind now, an assembly hall that is only used for twenty minutes in the day. We start at nine o'clock in the morning. The room is entirely vacant. At 9:10 there are 1,400 men in it. Now a system must be very elastic that will meet those conditions. We have very ample flues and we have a maximum blower, but we fix the velocity of air in the ducts so that we can at all times get the average amount of air wanted, and if there is an unusual crowd, by increasing the speed of the blower, we can get an amount of air so as to maintain the average per person at all times. The system of the average public school I find varies greatly. I have looked into a great many of them. As I said before, I have done very little work of that kind for the reason that it has not paid me to do it. I find in a number of public schools that the architect designed the room originally for 40 pupils. Later on it had 60 in it, and the flues, if they were designed at all with any reference to the matter, were designed with

the idea of having 40 pupils. If they have a blower system they attempt to overcome it by increasing the velocity. They get the quantity of air, but they get objectionable drafts. Until there is some definite means of regulating the number of pupils in a room of that kind, and regulating the janitor that runs the thing, we are going to have a certain amount of trouble. My theory is that you want to design a maximum system to meet the worst conditions that are possible in a particular building, and if those conditions do not exist then you are getting a little more air than you ordinarily would get, and it won't hurt you.

Mr. Harding :—With your permission I will refer to two or three little matters in this connection. That there is a difference between the introduction and discharge of a given volume of air and the changing of the air I have already pointed out. The usual size of rooms in school buildings in the only state where there is a law regulating the amount of air per pupil (Massachusetts) is, for 50 pupils, 32 by 28 feet, in which two sides are usually exposed and which contains approximately 10,000 cubic feet of space, the floor space being 18 square feet per pupil. The amount of air legally required, in one sense, although not definitely stated in the law, is 30 cubic feet of air per pupil, which is equivalent, the room containing about 10,000 cubic feet of space, to changing the air 6½ times per hour. In other words, the total number of cubic feet introduced and removed from the room per hour is equivalent to 6½ times the cubic space of the room. Ventilation at its best is simply a process of dilution, that is, mixing with air partially impaired by breathing a percentage of fresh air which will raise its standard of purity to the desired point. Tests have been made, and one that I have in mind in a room ventilated in the manner that I have just described, giving a little more than 30 cubic feet of air per pupil per minute, gunpowder was burned in the flue and the smoke was allowed to go into the room. Now 6½ times the volume of air in that room was removed in an hour, but at the end of the hour the fumes of the gunpowder were still in the room. That proves that ventilation is a process of dilution, and that dilution should be sufficient to maintain a given standard. A perfect ventilation, which means a perfect renewal with an absolutely new supply of fresh air, is an impossibility.

In regard to exhausting the air and the desirability of an aspirating coil, or, as I understand Mr. Jellett's remarks, a coil of steam pipes placed in the top of the aspirating flues, or the flues of the building coming together in the central point of the attic and a coil placed in one large outlet before the air reaches the open at-

mosphere, as against the value of a fan in that position, I simply wish to allude to the well known principle that the draft in a chimney is due to the difference in specific gravity of the air on the outside of the building and the air passing through the flue and to the height of the chimney. Within given limits the velocity is increased by the height. Now, if the heat of the aspirating coil in the flue is applied at its top, its value in raising the temperature of the air passing out, consequently increasing the difference in specific gravity between this exhaust air and the air out of doors, amounts to very little, as the distance through which it passes in height from this coil is very slight. If the air was brought to a point nearer the basement and then heated, the value in velocity gained by the difference in specific gravity would be obtained. There is an objection to the use of a fan to produce this exhaust, in that it may be neglected. Barring that objection, the amount of coal burned to produce the heat in the aspirating coil, if put into power to operate the fan, would do many times more work.

Mr. B. H. Carpenter :—While I think that a fan with the same amount of coal would do the work as Mr. Harding says, yet I think that the same amount of coal put in the original fan in the basement, overcoming the unnecessary friction of putting in another fan, would produce the same amount of work. That is, I think the same amount of cooling power put into the first fan would do the work instead of putting in the second fan. It seems to me it is merely a question of using a little more coal or a little more power at the fan in order to make that perfect ventilation. I have used flues in the three different ways spoken of, running the flues directly outside in the open air, without any power or assistance, and also running the flues out and connecting them to one flue in the attic and then up. In doing that, instead of putting the coils in the chamber in which they are gathered, I put the steam coil in the different flues before they are gathered in the attic. The reason for doing that was that if the main chamber were heated, that part being on the gravity system, the winds might have a different effect with different flues. A flue in one part of the room may be ventilating very rapidly and the other side may be standing still. So if we heat the different flues in different parts of the building they would all have that upward tendency and all be ventilating to better advantage. I would like to ask some of the members if they have have had any experience with locating the heater at the base of the flues, or what their experience is, and whether they derived better results from one main heater.

Mr. Jellett :—I will clear up a little of the doubt that has been

thrown on the central aspirating coil. I have used coils in the individual flues as Mr. Carpenter describes, and I found that when those same flues opened out in the cold attic I get back to my original condition to some extent ; that the galvanized ducts which connect with the central chamber are chilled, and the velocity of the air created by the coils in the brick wall-flues is largely lost in transmission to the central outlet. My experience is that by the pressure of a fan I get a positive uptake movement in the flues. When I get to the attic, that would be naturally retarded by the chilling effect described above. I then place my aspirating coil to lighten the air and create a vacuum at the head of the ducts which are all pitched toward that point. Then I have a flue some 10 or 15 feet long and I have a mass of heat centralized and the friction reduced where the mains come together. My experience has been that I have attained fully as good results in every case, and in many cases where I have had a pitched roof and a large attic I have noted better results, with the pressure of the fan below the aspirating coil in the central chamber. I have tried placing aspirating coils at the base of a main shaft that necessarily implies, in a building three or four stories high, that you pull your ventilation down first and then enter the base of this shaft. I have had, in some cases, very good results from that. But it is an expensive thing to get the ducts properly proportioned. In hospital practice I have used an exhaust fan instead of an aspirating coil, because, in insane hospitals particularly, the class of patients are more dirty and a very much larger amount of air is required, and I can put it under the control of an intelligent engineer and his assistants. In one hospital for insane I have five exhaust fans and five force fans. The exhaust fans are run by electric motors. The blowers in the basement are run by engines. There is a chief engineer and eleven assistants, and it is one man's business to follow the heating and ventilating. It is quite a distace through the tunnels to attend to all these fans. Then there is heating the water and the cooking apparatus and various things. They have one man there whose business it is to look after all these things. This is entirely a different condition from the average public school, where the janitor has a great many things to do, and, besides that, he is somewhat of an amateur politician and that takes some part of his time. My experience is that with that class of men the simpler form you have the better. You want to design a system that the most ignorant janitor cannot tamper with. Until such a time as the average board of education appreciates heating and ventilation at its true value and looks on the educa-

tion of children apart from politics, we will have trouble in the handling of even the best designed systems.

Mr. Quay :—I would like to ask Mr. Carpenter how many square feet of surface he has used in the 8-room school house that he has mentioned.

Mr. Carpenter :—The school that I was speaking of awhile ago has 2,600 feet of 1-inch pipe. Speaking of it in connection with fans, we generally speak of it as 2,600 feet of heating surface. But it is not that; it is 2,600 feet of 1-inch pipe. Of course the buildings vary largely. In some of the schools that we have heated the halls are equal to all the rooms, so that, necessarily, the coils must vary in size and also the fans. We have them running from 22 to 26, I might say. I wanted to say in connection with this question of the louvers that in putting a fan system into an old building we had just that result that Mr. Jellett speaks of in ventilating from the attic. There were louvers pointed in all four directions and if the wind came from any one direction it shut right down in that corner. We avoid that to some extent by building on the inside of the louver a frame with slots across running horizontally and then vertically up and down. We put on strips of light oil cloth, or oiled silk, so that when the wind blew against that it tightened it up while generally speaking the joints stood a little open and allowed the air to pass on up. After that we had no trouble from that point.

Mr. Jellett :—There is a suggestion I might make to some of the members. There is a form of damper made that has been used in England to prevent down drafts. It is made of mica. Mica can be made very thin and light and is easily handled. I have had several specifications made by a leading firm of architects in Philadelphia by which they called for all ventilating flues liable to down drafts to be furnished with mica louvers. Those mica louvers are very light. They are just pivoted with wires and hung in the flue. They are hung directly back of the out-take register. A down draft will instantly close them. The mica is comparatively inexepensive and can be procured in the different cities, and it is a permanent thing. I do not know that any of the men present have used it at all, and I simply offer that as a suggestion that it is a valuable material for any such purpose.

Mr. Harding :—There is a theoretical point in regard to a central aspirating chimney for a schoolhouse where the exhaust flues from the different rooms are brought down to the basement and the air enters the chimney at that point. The air goes down, then up, and when it reaches the level from which it started the ventilator upstairs is at the end of an inverted siphon with both legs the

same length. Consequently, until the air has got above where it started nothing has been done to increase the circulation. The circulation is not accelerated until the leg of the siphon which is in the aspirating chimney becomes the longer. Hence the cost of that duct, running from the second story to the basement, was money thrown away. When the air enters the aspirating chimney at the basement it mingles with air from other stories or comes in contact with the stack heater which gives an upward tendency. So many heat units are given out by the stack heater which creates a difference in specific gravity and increases the draft. The effect of these heat units can be made available without the expense of the down flue from the second story by connecting the first story ventilators, which are just above the basement, into the bottom of the aspirating chimney and bringing the exhaust air from the first story only into contact with the stack heater. That amount of air will take up the heat units, and the second story currents will enter the chimney at its level and mix with the volume of air from below, and the heat units will be distributed throughout the entire mass derived from the different inlets from the first and second stories. I have endeavored to show that you gain nothing by bringing the air down, inasmuch as the effect thus produced is counterbalanced by the waste of power to bring it down.

Mr. Barron :—I would like to ask Mr. Jellett his opinion of changing the air, using the same air over night, as Mr. Waters describes in his paper and as Mr. Carpenter provides for. Modern research shows that the air is full of animal life, and it seems to me it is a good way to cultivate micro-organisms by using the same air over and over. In all the schools that I have ever heated with direct radiation, nobody has ever complained about ventilation, and they save coal, but the point Mr. Waters is getting at is perfect ventilation, as I understand it.

Mr. Jellett :—I will answer that in this way : theoretical ventilation is one thing and practical ventilation is another. That we all know. We try to get as near nature as we can, which would be absolutely pure air. We take a given amount of air space, build walls around it, put a roof on it and put people in it, and gas jets and other things that vitiate it. We can only hope to minimize the danger. As long as these conditions exist we will not get absolutely pure air. A great many failures have been due to the improper placing of registers. I generally try to get as complete a circuit of air through the room as I can. When the air is delivered from a blower system, from a time, say, one or two hours before the assembling of the people, so that the room is as pure as

you get it under ordinary conditions and it is maintained all day long and for some time after people are dismissed, I do not see that there is much to be gained by keeping it running all night. Theoretically there is, but practically the difference in the degree of vitiation in a room is hardly noticeable. If you run a fan from five in the afternoon until six in the morning, you have 13 hours continuous running. There is no vitiation going on in the meantime, and I think it is an unwarranted use of air, because it is doing nobody any particular good. The difference in degrees of vitiation is almost imperceptible after a given time, provided the whole system is well designed and well placed so that the circulation is thorough. I should not run a fan all night in an empty building, I am free to say, under those conditions.

Mr. Baldwin :—There is one point, I believe, that has been overlooked in all this discussion. The discussion has been very able and has brought out a good many fine points. The point that I refer to is that when flues terminate in an attic space, some run through inside walls and some run through outside walls to that space. I have frequently found air going up in the inside one and going down in the outside one, the air actually returning into the room again. In an attic space, even with an aspirator above it, I have known this to happen. I have known it to happen in a hospital here in New York where the attic space alone is used for that purpose, and I have found that the same flue in cold weather carried straight through the top of the wall, worked nicely.

Mr. Harding :—In relation to that matter I believe it to be true that in the modern practice of ventilating no one who makes any pretension to be up in that line ever puts a flue in an exposed wall. A short time ago I made a contract for heating an isolated public building. The architect wanted several lines of ventilating pipes running up in recesses in the walls into the roof space, in which there was a tower with open louvers, ventilators being placed in the pipes near the floor. I asked him what they were for. He said for ventilation. I said, "With what object,to introduce fresh air or take out foul air?" He said, "Why do you ask that question?" I said, "Because it occurred to me that it might be possible it was to remove the foul air." He said, "Certainly, that is my idea." I said, "It is beyond any question that it will introduce fresh air but it will not take out foul air."

Mr. Baldwin :—I have a big contract on hand now and there is not a ventilating flue in the building but is in the outside wall, for the simple reason that the floors are all open and there are no inside walls to put them in. I will explain, though, how we are going to

endeavor, at least, to overcome that difficulty. We propose to use galvanized lining in the vent flues, and on the outside wall of the lining at least to put an inch board on the outside of the flue, and outside of that to put a tin cover to prevent the moisture striking through the wood. Mineral wool, you know, slips down. I have already used the board in Vanderbilt Memorial Hall at Yale College. I found in my experience that those flues nearly always draw like any other chimneys, even without any assitance from the inside. I do not defend flues on outside walls, however. I simply refer to this thing to show that the circulation through continues sometimes.

Mr. Harding :—I simply rise to qualify the statement that in modern practice the engineer never puts his flues in outside walls. He never does so if he can help it. When he does so, the necessity for insulation in cold weather has been pointed out by Mr. Baldwin.

TESTING OF STEAM RADIATORS.

BY PROF. CARPENTER, ITHACA, N. Y.

(Member of the Society).

The following paper will give in detail the results of experiments, extending over three years of time, which were made for the purpose of finding the amount of heat which would be transmitted through the walls of radiators when made of various materials and in various forms. The experiments were made solely for the purpose of obtaining coefficients which would be useful in the designing of heating apparatus, and while the writer is indebted to many of the most important manufacturers of radiators in this country for material, the experiments were made independent of any commercial interests and purely for scientific purposes. In advance of the description of the tests, the writer desires to say a few words regarding theoretical considerations and make a few remarks regarding the general problem of heat transmission.

Theoretical Considerations.—The radiator, so far as theory is concerned, may represent any metallic construction through which heat passes. The source of heat may be fire, steam, or water ; the metallic construction cast or wrought iron, tin or brass. The heat which passes through is usefully applied in elevating the temperature of the surrounding air.

The heat in passing through any metallic surface raises its temperature an amount which depends upon the facility with which heat is conducted by the body and discharged from the outer surface. The phenomena of the flow of heat through any metallic substance can be illustrated by the sketch in Fig. 1. If E represents the source of heat, and A B C D a section of a metallic wall surrounding, the flow of heat takes place through the metallic surface, then the solid metal, and finally the outer surface.

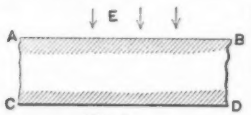

Fig. 1.

It is noted that the heat meets with three distinct classes of resistance ; first, that due to the inner wall ; second, that due to the thickness of material ; and third, that due to the outer surface.

The first and third resistances are due to change of media, and when the material under consideration is a good conductor, constitute the principal portion of the resistance to the passage of heat.

If the resistance on the inner surface A B is small and that on the outer surface C D is great, the temperature of the metallic body will approach that of the source of heat, for the reason that the heat will be delivered to the surface C D faster than it is discharged. In this case the thickness of the material composing the radiator is immaterial, and the rate at which heat will pass will depend entirely upon the rapidity with which it can be discharged from the outer surface.

To a certain extent, and so far as the condition described be true, the character of the material of the radiator may make no difference in the amount of heat transmitted. If the sum of thermal resistances in passing the inner surface and the body of the material is less than that of leaving the outer surface, the efficiency will be independent of the material used and of the thickness, but will be a function of the condition and character of the outer surface. In the case of radiators as ordinarily used in steam or hot water heating, we find from experiment that the principal resistance which the heat meets in its flow from the inside outward is that of the outer surface. This is due largely to the fact that air absorbs heat slowly from any metallic body.

A certain portion of the heat passes through the outer surface of the radiator in direct lines by a method which we term "radiation." Heat is also taken away by a system of circulation in which particles of air are brought directly in contact with the heated radiator. These are raised in temperature and conveyed to other portions of the room. This method is termed "convection." Some heat, although in the case of steam heating the amount is less than can be measured, is removed by the propagation of heat from particle to particle without corresponding motion. This is termed "conduction."

Practically air is heated only by convection, that is, by the rubbing of the particles against some body of a higher temperature than itself. Air absorbs almost no radiant heat and is one of the poorest conductors known. If the whole atmosphere were concerned we should find that some radiant heat had been absorbed, but even then it is a small amount, and for considerations of heating, the radiant heat absorbed by air can be considered as nothing. Such heat is, however, absorbed to a certain extent by the walls of a room and by solid bodies, and in this way can be returned to the air by convection.

The amount of radiant heat given off or absorbed is a function of the surface. Metallic or bright surfaces give off very little radiant heat. The absorbing and emissive powers of surfaces are the same. A surface coated with lamp black absorbs practically all the heat that reaches it. The following table* is of interest in this connection as showing the relative absorbing and emissive powers of various surfaces at the boiling temperature.

Lamp black	100	Indian ink	85	Polished brass	7
White lead	100	Shellac	72	Copper	7
Paper	98	Steel	17	Polished gold	3
Glass	90	Platinum	17	Polished silver	3

This table is not, in the absence of direct experiment, to be considered as applying to radiators with certainty, since it may be true that the capacity to give off heat by convection will increase as that for radiation decreases. The convection is a function of the rapidity of motion with which of particles of the air come in contact with the surface.

These general considerations would lead us to expect, that the best results would be obtained from radiators whose surfaces are most efficient for delivering radiant heat, and which are of such form as to induce the most rapid circulation of air. Before giving the results of the experiments performed, it seems best to give a technical definition of the unit employed as a measure of heat.

Unit of Heat.—It should be noted that heat is a complex force, one element of which is "temperature" which can be measured by a thermometer. The other element, "entropy," can not be readily measured, but the total available heat, which is the product of these two elements, can be measured by its capacity to heat any other substance, as, for instance, a given weight of water. The unit for heat measurements adopted in English speaking countries, is that required to raise one pound of water one degree in temperature. Strictly speaking the standard temperature is from 39 to 40 degrees Fahrenheit, although the variation in the thermometric scale is of little practical importance. This unit is called a British Thermal Unit, for which we will use the abbreviated symbol B. T. U. In some radiator trials the heat has been measured and the results expressed by the number of pounds of steam condensed. This is an indefinite standard, as the amount of heat contained in one pound of steam varies with its pressure and the amount of moisture contained. A thermal unit is, however, a definite and simple standard. It expresses the capacity to heat water. One B. T. U. would signify sufficient heat to raise the temperature of one pound of water one Fahrenheit degree; two thermal units is the heat sufficient to raise it two degrees, etc.

* Deschanet's Natural Philosophy.

Experiments Showing Various Rates of Transmission.—As bearing directly upon the above subjects, the writer planned a series of experiments which were conducted by E. T. Adams and M. H. Gerry in Sibley College during the winter of 1893-4. The results of these experiments show that the amount of heat transmitted does not depend so much upon the kind of metal as upon the materials in contact with the metal on both sides. The experiments performed were quite elaborate ones, and few of the details will be given here. Every precaution was taken to secure accuracy.

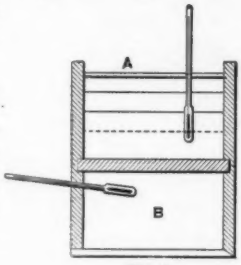

Fig. 2.

The heat measurements were made with an apparatus arranged as in Fig. 2. The box A was fitted so that plates of cast or wrought iron of various thickness could be used as a bottom. The box B directly beneath the box A was so constructed that steam, air, oil, or water of a given temperature could be supplied and would transmit its heat upward through the bottom of the box A. The heat thus transmitted was measured by its effect on the temperature of the water in box A. The results were reduced to thermal units passing through one square foot of metal per hour, for each degee difference in temperature in box B and box A.

We see from Table I that when steam and water are in contact with the plates considerable difference in the results were obtained by

TABLE I.—HEAT TRANSMITTED IN THERMAL UNITS FOR EACH SQUARE FOOT PER HOUR AND PER DEGREE DIFFERENCE OF TEMPERATURE.

Difference of Temperature of the two sides of the Plate, Deg Fah.	Steam to Water.				Lard Oil to Water.		Air to Water.	
	Clean Wrought Iron $\frac{1}{4}$ inch thick	Clean Cast Iron $\frac{7}{16}$ inch thick.	Wrought Iron Plate and Scale 1½ inches thick.	Cast Iron Plate and Scale 1½ inches thick.	Clean Cast Iron Plate $\frac{1}{4}$ inch thick.	Cast Iron Plate and Scale.	Clean Cast Iron $\frac{1}{4}$ inch thick.	Cast Iron Plate and Scale.
25	28.8	21	2.7	1.8	6.5	4	1.2	0.15
50	60.0	48	5.5	3.6	13	8	2.5	0.3
75	96.0	84	8.2	5.4	19.5	12	3.7	0.45
100	150.0	127	11	7.3	26	16	5	0.6
125	228	185	13.7	9.1	31.5	20	6.2	0.75
150	348	255	16.5	10.9	39	24	7.5	0 9
175			19.2	12.7	45.5	28	8.7	1.05
200			22	14.6	52	32	10	1.2
300			33	21.9	48	78	15	1.8
400			44	30.2			20	2.4
500							25	3.0
600								3.6

varying the thickness of the plate in the bottom of the vessel A. But when air is on one side, the results were little affected by varying the nature and thickness of the plate. The experiments were made with a clean cast iron plate, also with wrought iron plate, and then with each of these plates covered with a thick layer of boiler scale, neatly fitted to the plate. In the latter case the heat had to pass through both the scale and the plate.

The table is of interest, since it shows that with the same material for heat transmission, and with the same difference of temperature, there is a great difference in the results. These depend more upon the material which receives or takes up heat than upon the material which conducts it. It can be readily seen, however, that such would not have been the case with poor conductors.

Thus the heat transmission through iron, from steam to water, varies from 25 to 75 times as much as that transmitted through the same iron plate from air to water. When the heat was passing from steam to water there was a sensible difference, due to the material and thickness of the plates used, but when passing from air to water this difference wholly disappeared.

In passing from steam to water the rate of transmission increases very rapidly with increase in difference of temperature. The results given in the table are the total results divided by the difference of temperature. These results show that the common hypothesis, which is that heat transmission per degree difference of temperature is constant, is far from true. This fact is not new, although it is contrary to the law of heat transmission as stated by Sir Isaac Newton. The fact that the capacity for heat transmission increases at a much greater rate than the difference of temperature was first pointed out by the French physicists Dulong and Petit and fully exemplified by the French savant, Peclet.

The important practical application is this ; the capacity of a radiator for the transmission of heat is increased very rapidly by increasing the difference of temperature between the fluid within the radiator and that without. If comparison of one radiator with another is to be made, both the inside and outside temperature should be the same, and farther, the surrounding air should be still, or else have a uniform motion in either case. Large results are obtained by making the difference of temperature very great or by increasing the rapidity of motion of the surrounding air. In other words, the efficiency of a radiator will be greatly increased by increasing the steam pressure or by forcibly bringing the air in contact with it. With these general remarks I will proceed to the description of the tests made.

Radiator Tests.— I do not know of any species of testing in which the difficulties of obtaining uniform results in successive trials are so great as in determining the heat discharged from radiators. The results are greatly affected by small variations in temperature, by irregular air-currents, and even by the amount of moisture contained in the steam. Obscure conditions of little apparent importance, and often disregarded, may greatly influence the results. In testing steam radiators in Sibley College the following scheme was adopted for measurement of the heat discharged and for operating the radiators.

First, the steam supplied was delivered to the radiator through a reducing valve which would maintain a constant pressure during any given run. Second, the amount of moisture in the steam supplied was carefully measured by a calorimeter, and corrections made to the result for the water entrained in the steam. Third, the pressure and temperature of the steam in the radiator was measured by accurate gauges and thermometers. Fourth, the amount of heat passing through the radiator was measured by weighing the condensed steam, measuring its temperature, and computing by this means the heat discharged.

The heat supplied was computed by knowing the weight, the percentage of moisture, and the heat contained in one pound of steam. Various methods were tried for drawing off the condensed water ; in some instances a trap was used, but better results were obtained by employing a water gauge glass and drawing off the water of condensation by hand, at such a rate as to maintain a constant level in the glass. To prevent loss by evaporation, this water needs to be received either into a vessel containing some cold water, or else into one with a tight cover, the latter being generally preferred.

Fifth, the air from the radiator must be effectually removed. Large errors are caused by leaving varying amounts of air in the radiator. The ordinary air-valve is often very unsatisfactory for this purpose ; if used, it must be closely watched or the results may be seriously affected.

The heat discharged through the radiator is in all cases computed by taking the difference between that received and that discharged. This result is accurate and easily obtained. The heat which is transmitted is utilized in warming the air and objects in the room, and to supply losses from various causes, which take place constantly. This heat is diffused so rapidly, and used in so many ways, that it is practically impossible to measure it. It is, of course, equal to that which passes through the radiator. The heating effect on air would be measured, in any case, by multiplying the increase in

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temperature by the weight of air heated and by the specific heat of one pound of air. These quantities are difficult to measure. In the case of indirect heating it is a matter of importance to find what percentage of the heat is taken up by the air flowing over the radiators. In this case the method would be to determine the temperature before and after passing the radiator by thermometers carefully shielded from the effects of radiant heat. The velocity of air is to be measured ; this, multiplied by area of cross-section and by the specific weight, will give the total weight of air affected. The velocity of air is usually measured by an anemometer, which consists of a series of fans mounted on a pivot, and connected to a recording mechanism graduated to read velocity of air in feet per minute or feet per second. This instrument is calibrated by swinging it through a mass of still air at a known velocity and noting the results. The anemometer is, as a rule, not very reliable, and if velocity determinations are made with it, the average of a large number of readings taken from different parts of the flue should be used.

The velocity of air can be computed approximately by its fall in pressure. This method is very complicated, but with delicate instruments is probably as accurate as with the anemometer.

The formulæ for expressing the velocity of air for a pipe of uniformly circular section with a diameter of, d, feet is

$$u_0 = \left(1 - 0.643 \frac{p_1}{p_0}\right) 280.5 \sqrt{\frac{Td}{l}}^*$$

in which u_0 = velocity, feet per second, at point of initial pressure

p_0 = initial pressure, pounds per square inch.

p_1 = pressure at any other point.

d = diameter of pipe in feet.

T = 460 plus temperature.

l = length of pipe between parts where pressure is increased.

Measurement of Surface.—Radiators are in every case rated by the number of square feet of surface of metal exposed to the air. Many radiators are extremely irregular in form, and it is a matter of no little difficulty to determine the extent of this outside surface with accuracy. There seems to be no way except by actually measuring, with tape or string, minute portions of the surface, and then by a series of additions or multiplications compute the total. One way which was suggested was that of dipping the whole radiator into some limpid liquid and then comparing this result with the result obtained by dipping a plain surface of known area and of the same material, it being supposed that the amount of liquid retained on the

* Encyclopedia Britannica, Vol. XII, p. 491. Equation (lc) with numerical constants.

surface would be in proportion to the actual surface. This method was tried, but without success, it being found that the amount of liquid retained was far from being proportional to the extent of surface.

The internal volume can be measured quite accurately by filling with water and noting the volume of water required. The external volume can be determined by measuring the total water displaced when the radiator is immersed in a tank which had been previously filled to a given level. There is, however, no known relation between volume and surface, especially when irregular or convoluted forms are common. The weight can readily be determined, but even that, in addition to the other quantities, will not give sufficient information to compute the exterior surface. The results of measurement of irregular surfaces by different observers give results which are essentially different, although the utmost care be taken. In the measurement of the same radiators by three different sets of observers, all using every precaution possible, the variation in results amounted to as much as five per cent in extreme cases.

Tests of Jackson and Kelsey, 1891.—These were the first radiator tests made at Sibley College. The plan first adopted consisted in arranging two radiators in a limited space and connected together in such a manner as to be essentially under the same conditions. The arrangement adopted is shown in the accompanying figure, Fig. 3. Steam was supplied from an intermediate vessel of comparatively large size, its quality accurately determined by calorimeters, the condensation caught and removed, as previously explained. The radiators being confined in a limited space, the opportunity for radiation would be very much reduced as compared with ordinary conditions. Air was supplied at the bottom and passed off at the top. The boxes which contained the radiator were made of wood and covered outside and in with double layers of building paper so as to make an air space.

Steam was received at one end of the radiator, and the the same radiator was left in one of the compartments, the object of this being to give us a means of directly comparing one with another. The radiator used for this means of comparison, and which we call the standard, was an old pipe radiator with a small tube set inside of an inch tube, the connections being made as shown in the cuts. The radiators tested in this way and compared with the standard are principally shown in the pictures accompanying the article, and were as follows :

Perfection, steam 13 sections, 38 inches high, Fig 7.

Perfection, direct-indirect, 12 sections, 37¾ inches high, tested both with dampers open and closed.

Nason, Fig. 5, wrought iron pipe, 16 sections in three rows, 35 inches high.

Royal Union, 11 sections, 38 inches high.

Bundy, 10 sections in three rows, 36 inches high.

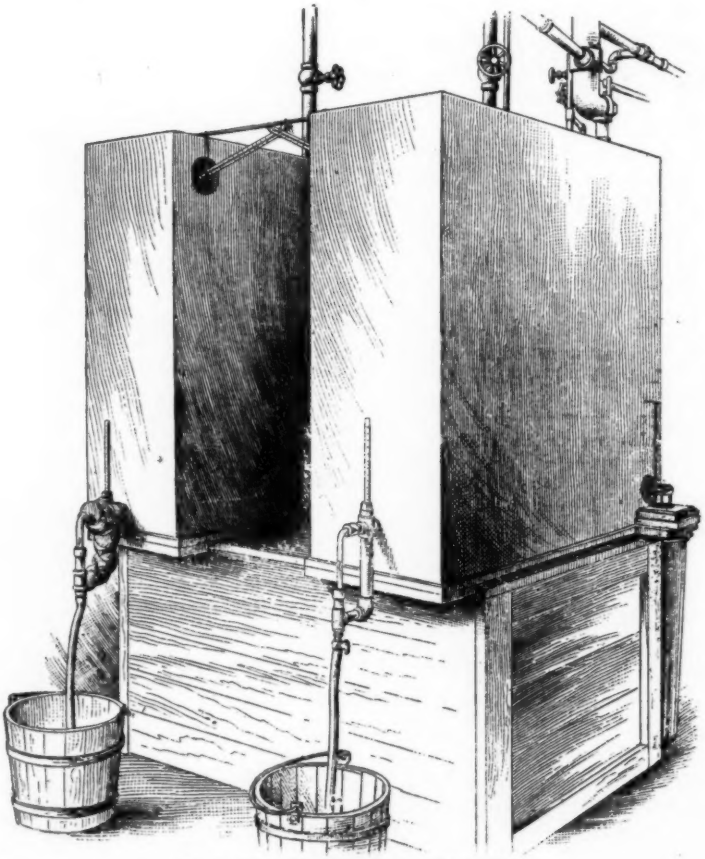

Fig 3.—GENERAL VIEW OF APPARATUS.

Perfection, pin indirect ; this as tested consisted of six sections, arranged in the boxes as for the other tests.

One radiator shown in the drawing, taken from one of the

University buildings, maker's name unknown, was also tested ; this consisted of 15 sections 38 inches in height.

In these tests the radiators were all surrounded with air of comparatively high temperature, and little heat could be given off by

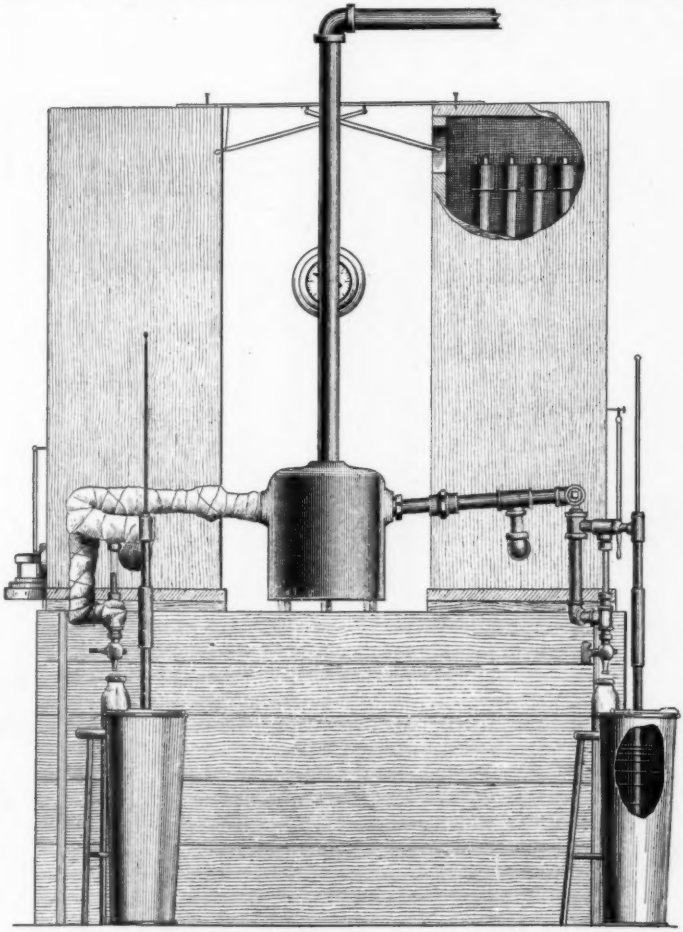

FIG. 4.—ELEVATION OF APPARATUS.

direct radiation. The results are of absolute value only as applying to radiators when tested under similar conditions or in very warm weather, but they do give interesting comparative results.

Roughly speaking, the amount of heat given off under these conditions, and with the surrounding temperature not far from 200 de-

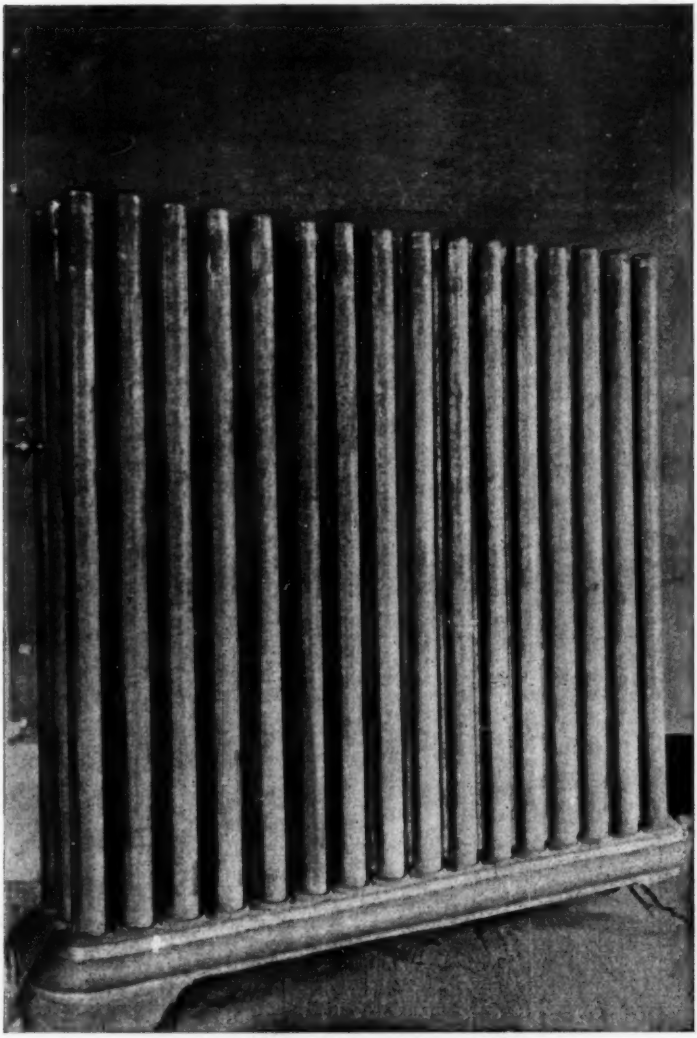

Fig. 5.—THE NASON RADIATOR WITH TOP REMOVED.

grees, gave us only about one-third of the heat transmission per degree difference in temperature that we obtained when the sur-

rounding air was about 70 degrees. The results of this test are shown in Table II.

All the other tests were made with radiators standing either in a large room or in a comparatively large compartment, so that they were tested practically under the conditions of actual use. In the tests which follow (see Table II), made by Jackson and Kelsey, four radiators were connected so as to be tested continuously, and so as to work as nearly as possible under similar conditions. The radiators for these tests were in a large room and were set some distance apart, so that it was not believed they would be affected by radiant heat.

Tests of Camp and Woodward.—The tests of 1892 were made by Mr. Charles F. Camp and Arthur H. Woodward under the direction of the author, and are remarkable for the accuracy and care with

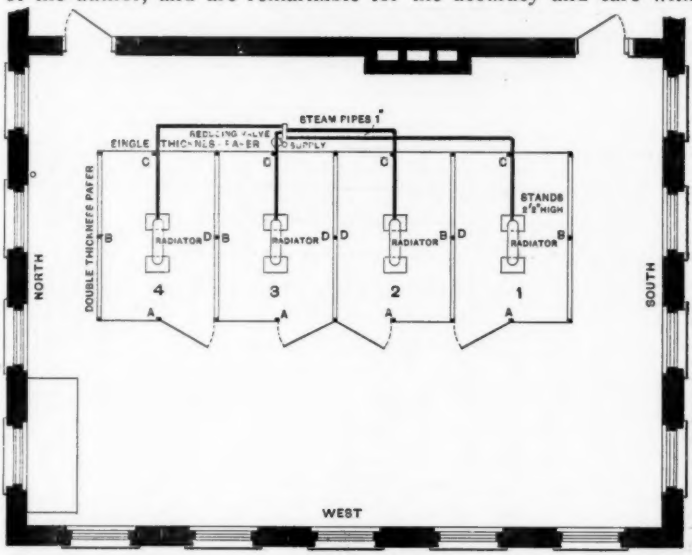

Fig. 6.

which the investigations were conducted. For this test four small compartments were constructed in a large room, the arrangement being shown in the accompanying plan, Fig. 6. The compartments were constructed by using heavy building paper nailed to a wooden framework, each compartment being 7 by 10 feet, and about 8 feet in height. A general view of the framework of the compartments, with radiators in place for testing, is shown in Fig. 7. A view of the inside of one of the compartments, with radiators and apparatus,

TABLE II.—GENERAL RESULTS.—TEST BY JACKSON and KELSEY. { Height, in most cases, about 38 inches. / Height of Whittier, 2 feet.

	Name of Maker.	General Character.	Rated Surface, Square Feet.	Measured Surface, Square Feet.	Total Volume, Cubic Feet.	Ratio of Volume in Cubic Feet to Rated Surface.	Ratio of Volume to Measured Surface.	Rows of Tubes.	Weight, Pounds	Test of Radiators Enclosed in Small Boxes.									Tests Made in Large Room.					
										Temperature of Steam.	Average Temp. of Air Surrounding.	B. T. U. per Sq. Ft. per Hour, Actual Surface.	B. T. U. per Sq. Ft. per Hour, Solid Surface.	Temp. of Air Entering on Radiator.	Temperature of Air Leaving Radiator.	B. T. U. per Sq. Ft. per Hour, per Deg. Difference of Temperature.	B. T. U. per Sq. Ft. per Hour, per Deg. Difference of Temperature.	Anemometer Revolutions per Sq. Ft. per Hr	Temperature of Steam.	Temperature of Air	Quality of Steam.	B. T. U. per Sq. Ft. of Rated Surface per Hour, and per Degree Difference.	Same per Sq. Ft. Actual Surface.
A	Not Known	Wrought Iron Vertical Pipes, Not Connected	52.	53.6	.....	.....		3	462	228	184	54 .8	....	67	202	.62								
B	Michigan (Perfection) Radiator Co.	Cast Iron for Hot Water								228	135	58 .8	56 .5	67	204									
		Elliptic Section	52.	49.9	1.61	.031	.032	1	378	221	132	56 .0	53 .1			.632	.676	287						
C	Not Known	Cast Iron, Two Tubes Joined at Top	9	51.5	1.06	.017	.021	2	344	226	140	54 .7	....	78	206	.634	.541	272						
D	Nason	Wrought Iron Pipe, Separate Tubes	48	46.9	0.744	.016	.017	2	265	224	134	58 .9	57 .6	75	199	.669	654	292	227	6	81.	99.	1 79	1 83
E	A. A. Griffing Iron Co.	Cast Iron, Old Form of Radiator	..	79.	1.83	.014	.017	3	587	224	139	40.	.	70	208	.465	.490	188	227.6	78.5	99.	1 .64	1.64	
F	Michigan { Direct . Perfection { Indirect ..	Cast Iron, Special Air Flues, Direct Indirect, Dampers Open	48.	48.	1 51	.031	031	1	405	227	138	58 .9	58 9	69	204	.664	.664	200	225.	87.5	98.5			
		Cast Iron, Special Air Flues, Direct Indirect, Dampers Closed	48.	48.	1.51	.031	.031	1	405	223	147	62 .2	62 .2	70	202	.671	.674	301	227.6	78.	99	1.36	1 55	
G	Michigan Radiator Co.	Gold's Pin, Pin Surfaces, ... { Cast Iron	66.	58.2	1.22	.018	.021	1	267	223	132	41 .2	36 .4	65	197	.434	.38	257	.....	.....	.....	.....	.....	.....
H	H. B. Smith ..... { Reeds	Cast Iron, Swelled Form	52.	50.	1.20	.0235	.024	2	397													1.44		
																			227.6	78.2	99.	2 10		
I	H. B. Smith ..... { Royal Union	Cast Iron, Three Columns Joined	49.5	51.5	1.47	.030	.028	3	370										226.					
J	Pierce	Ideal, Cast Iron, Hot Water	36.	39.	1.13	.031		1	252										226.	85.	98 5	2.08		
K		Whittier	50		0.6	.012		1	280										226.	86.	98.	1.61	1.61	
																			226.	84.	98.5	1.13		

for testing, is shown in Fig. 8. A view showing reducing valve and steam connections is given in Fig 9. The walls of these compartments were open at the bottom, both in front and back, and were also open at the top, so that the radiators were protected from heat

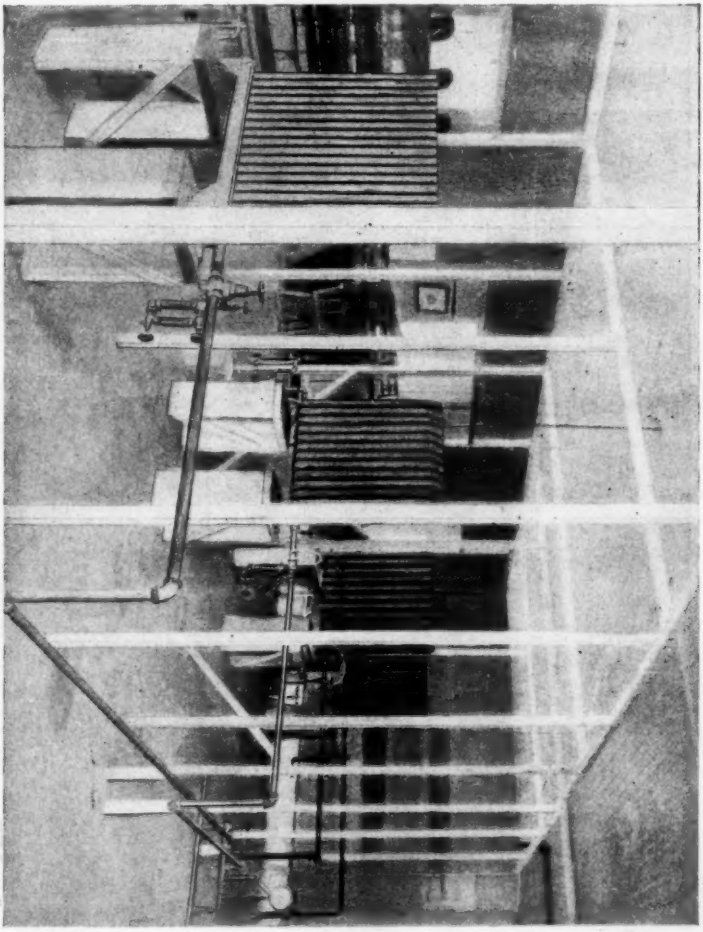

FIG. 7.—GENERAL VIEW OF THE APPARATUS BEFORE THE PAPER WAS PUT ON.

interchanges, and, as nearly as possible, tested under the same conditions. The walls did not interfere with the free circulation of air around the radiators, the conditions being as fair as was possible to devise.

The plan adopted for this test was essentially different from that of Messrs. Kelsey and Jackson of the year before. It was intended

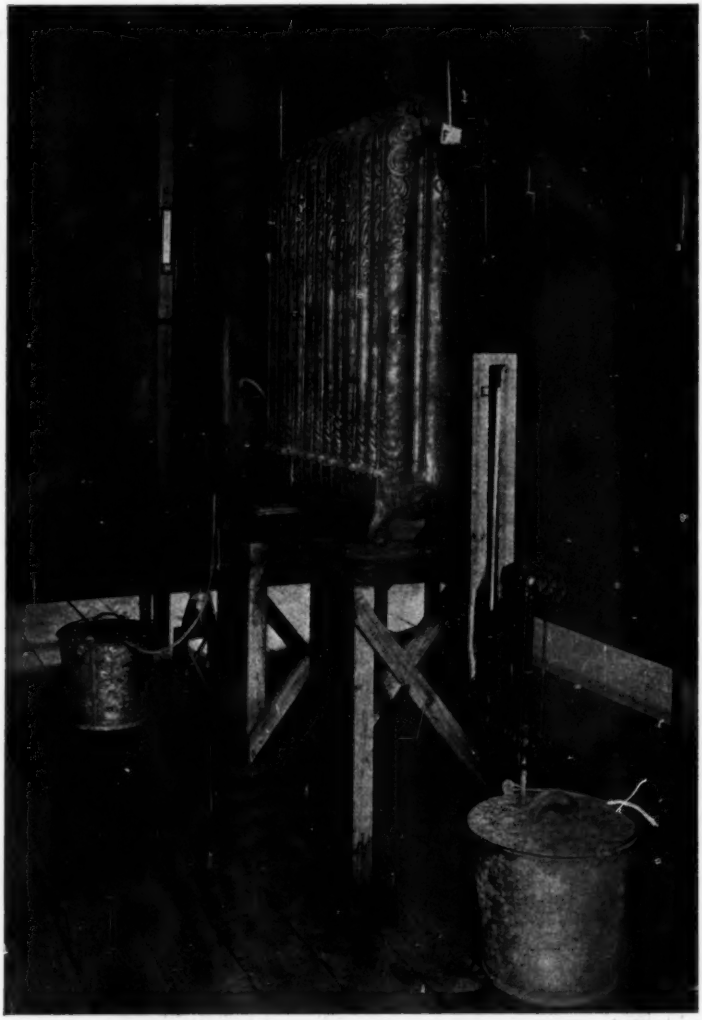

FIG. 8.—INTERIOR OF COMPARTMENT SHOWING PERFECTION RADIATOR IN PLACE.

to test four radiators at one time, arranged in a certain order, one in each compartment. It was then intended to re-arrange the radia-

tors and repeat the tests until each radiator should have a test in each compartment. The carrying out of this plan, which was com-

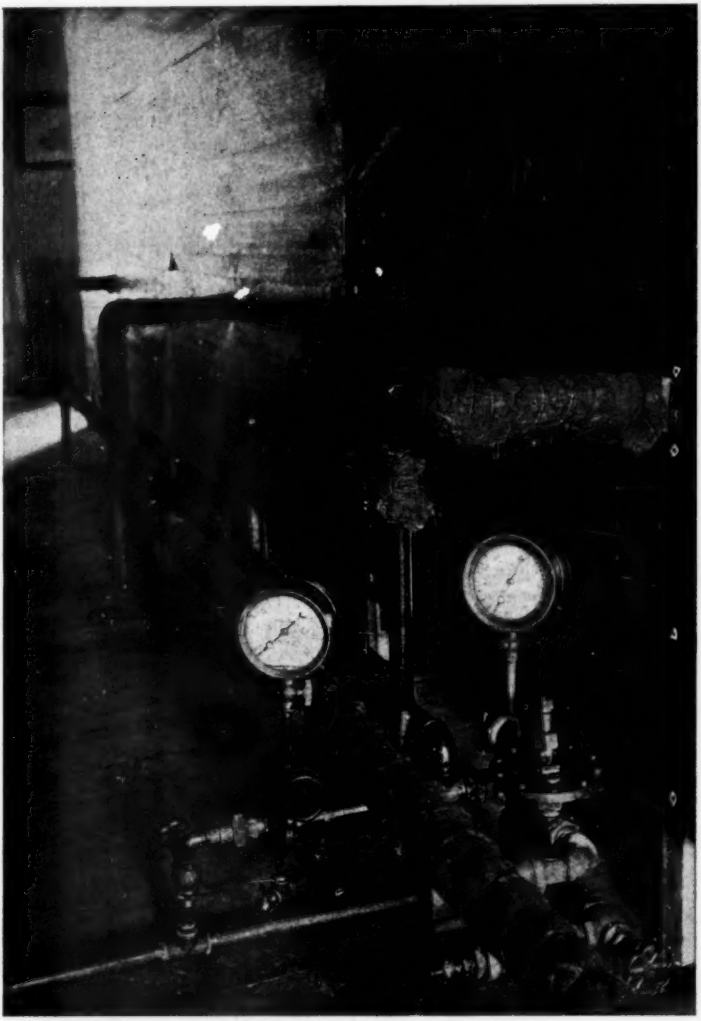

Fig. 9.—THE STEAM CONNECTIONS.

paratively simple in its conception, led to many unexpected difficulties. It was found on repeating experiments and taking every

precaution to secure accurate results, that frequently the discrepancy in results, or difference between the results obtained when test-

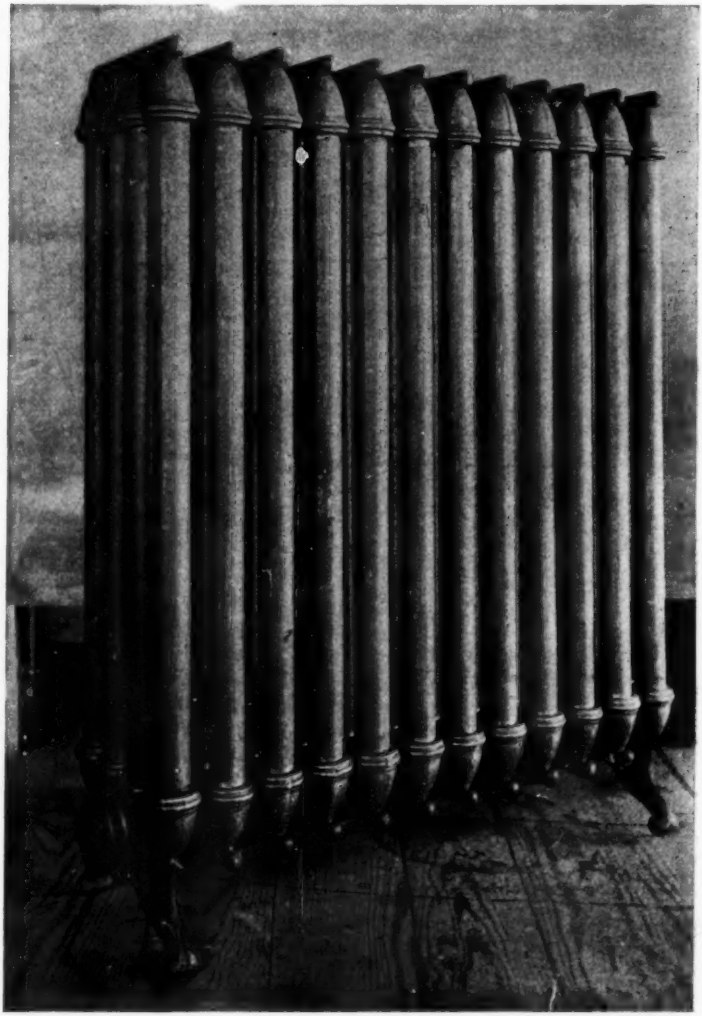

Fig. 10.—THE WESTERN HOT WATER RADIATOR.

ing the same radiators on different days, was greater than the difference between two radiators of different makes. This was a very dis-

couraging matter and led to a repetition and re-repetition of the work, in order to find, if possible, the cause of the discrepancy. This took so much time that only four radiators were tested, but as will be seen from a study of Table III, these were tested under nearly every condition imaginable.

The final conclusion was that a very slight variation in the motion of the external air was sufficient to sensibly affect the amount of heat given off by any of the radiators, and that when there was any sensible wind, although the windows might be closed, the radiator in the windward compartment would have its efficiency sensibly increased. As the walls of the surrounding room were of brick, this was a result entirely unexpected.

The radiators tested were as follows: I. Royal Union, 49.12 square feet surface, volume 1.47 cubic feet, weight 370 pounds, height 37 inches.

II. Reed, 48.63 square feet surface, 1.2 cubic feet volume, weight 397 pounds, height 37 inches.

III. Nason, 46.94 square feet surface, 0.744 cubic feet volume, weight 265 pounds, height 36 inches (Fig. 5).

IV. Perfection, 49.51 square feet, 1.61 cubic feet volume, weight 378 pounds, height 37¾ inches (Fig. 8).

The compartments were numbered 1, 2, 3, and 4, and arranged as shown in Fig. 5.

The first tests made were continued for three hours. It being found, however, that the difficulty of maintaining constant conditions was increased with the length of time, the time of test was later reduced to two hours, and then to one hour. The length of time of test does not in any case include the time taken to get all the conditions constant. After the conditions are constant then the time required should be sufficient to get observations enough to deduce an accurate average. In no test were there less than 20 observations recorded for each quantity, so that it would seem that every precaution was taken to secure accurate results.

The following observations were taken for each test: Temperature of outside air, temperature of radiator surface, temperature of condensed steam, temperature of compartment in four places, pressure of steam, barometer reading, quality of steam, weight of condensed steam.

Table III gives the average results of the various tests made by Messrs. Camp and Woodward. The coefficient of heat transmission, or the quantity of heat transmitted per degree difference in temperature and per square foot per hour, varies under different conditions for the same radiator—about 15 per cent, this variation

TABLE III.—RESULTS OF TESTS OF CAMP AND WOODWARD.

No.		Test No. 1.				Test No. 2.				Test No. 3.			
1	Duration, Hours	3	3	3	3	3	3	3	3	1	1	1	1
2	Compartment Number	1	2	3	4	1	2	3	4	1	2	3	4
3	Radiator Number	III	IV	I	II	IV	III	II	I	IV	III	II	I
4	Mean Steam Pressure by Gauge	3.9	3.95	4.0	3.95	3.65	3.70	3.75	3.70	4.18	4.23	4.28	4.23
5	Mean Absolute Steam Pressure	18.15	18 20	18.25	18.20	18.07	18.12	18.17	18.12	18.42	18.47	18.52	18.47
6	Temperature of Entering Steam	222.9	223.0	223.2	223.0	222.6	222.8	222.9	222.8	223.6	223.8	224.9	223.8
7	Mean Temperature of Compartment	74.9	75.2	73.9	72.2	75.7	77.7	75.8	73.5	86.3	88.9	88.0	86.9
8	Difference of Temperature, Steam and Air	148.0	147.8	149.2	150.8	146.9	145 1	147.1	149.3	137.3	134 9	135.9	136.9
9	Mean Temperature of Condensed Steam	196.5	155.5	208.5	199.8	157.2	176.4	178.7	147.1	147.9	174.6	167.4	165.1
10	Weights of Steam Condensed, pounds	39.75	98.66	97.13	96.46	31.20	35 15	38.15	41 00	8.09	10.56	11.36	11.62
11	Quality or Per Cent of Dry Steam	97.15	98.66	97.43	96.46	94 23	98.17	97.53	96.13	97.92	98.84	97.94	96.94
12	Total Heat in one pound of Steam supplied, B. T. U	1126.2	1137.1	1125.4	1116.0	1094.51	1132.35	126.26	1112.80	1130.23	1139.09	1130.51	1120.80
13	Total Heat in one pound of Condensed Steam above 32°	165.21	163.8	177.3	168.5	125.53	144.90	147.23	115.36	116.17	143.08	156 00	133.50
14	Heat Radiated per lb of Steam, B T. U	961.0	973.3	948.0	947.5	968.98	987.45	979.03	997.42	1014.06	996.01	974.51	987.39
15	Total Heat Radiated per hour, B. T U	38201 0	32228 0	42 82.0	39747.0	30232.0	34710.87	37349.99	40894.22	8193.60	10517 86	10770.43	11473 47
16	Heat Radiated, per hour and per degree difference of temperature, B T. U	86.06	72.68	94.45	87.86	68.60	79.80	84.62	91.30	79.67	77.96	79.23	83.80
17	Same, per square foot actual surface	1.835	1.456	1.922	1.825	1.374	1.700	1.736	1.858	1.196	1.650	1.626	1.705
18	Same, per square foot rated surface	1.791	1 397	1.908	1.688	1.319	1.602	1.627	1 844	1.147	1.624	1.523	1 092

Radiator No I, Royal Union. Radiator No. II, Reed. Radiator No. III, Nason. Radiator No IV, Perfection, with 13 sections.

TABLE III.—RESULTS OF TESTS OF CAMP AND WOODWARD (*Continued*).

No.		Test No 4.				Test No. 5.				Test No. 6.			
1	Duration, Hours	2	2	2	2	2	2	2	2	1	1	1	1
2	Compartment Number	1	2	3	4	1	2	3	4	1	2	3	4
3	Radiator Number	IV	III	II	I	IV	III	II	I	IV	III	II	I
4	Mean Steam Pressure by Gauge	4.49	4.54	4.59	4.54	4.28	4.33	4.38	4 33	4.78	4.83	4.88	4.83
5	Mean Absolute Steam Pressure	18.64	18.69	18.74	18.69	18.43	18.48	18.53	18.48	18.83	18.88	18.93	18.88
6	Temperature Entering Steam	224.3	224.4	224 5	224.4	223.7	223.8	223.9	223.8	224.8	224.9	225.1	224.9
7	Mean Temperature of Compartment	76.6	78.5	78.1	77.3	79 6	79.6	79.3	79.1	85 0	85.7	86.1	85.6
8	Difference of Temperature, Steam and Air	147.7	145.9	146.4	147 1	144.1	144.2	144 6	144.7	139.8	139.2	139.0	139.3
9	Mean Temperature of Condensed Steam	139 4	172 7	195.4	156 6	180 3	183.2	184.1	160.9	156.8	193.4	207.0	149.8
10	Weights of Steam Condensed, pounds	18.48	22.80	26.21	25.75	21.1	23.99	24.52	24.83	8.56	11.01	11.87	10 75
11	Quality or Per Cent of Dry Steam	98.61	97.20	98.09	97.00	97.91	97.88	97.99	96.70	97.68	98.57	98.02	97.03
12	Total Heat in one pound of Steam supplied, B. T. U.	1137.18	1123.56	1132.14	1121.66	1130.13	1129.90	1130 99	1118.59	1128.30	1136.87	1131 64	1122 13
13	Total Heat in one pound of Condensed Steam above 32°	107.63	141 16	164.9	194.94	148.84	151.97	152.68	129.26	125.14	162.18	175.83	118.00
14	Heat Radiated per lb. of Steam, B. T. U.	1029.55	982 40	968.05	956 72	981.29	977.93	978.31	989.33	1003.16	974.69	955.81	1004 04
15	Total Heat Radiated per hour, B T. U.	19026.08	22398.72	25372.59	25665.54	20616.90	23460.54	23988.16	24565.06	8587.05	10731.34	11345.47	10793 43
16	Heat Radiated, per hour and per degree difference of Temperature, B. T. U.	64.41	7 .93	86 66	87.58	71.54	81.35	82.95	84.88	61.42	77.09	81.62	77.48
17	Same, per square foot actual surface	1.291	1.636	1.780	1.783	1.433	1.733	1.708	1 726	1.233	1.641	1.676	1.577
18	Same, per square foot rated surface	1.238	1.602	1.666	1.709	1.376	1.694	1 595	1.714	1.182	1.604	1.569	1.563

Radiator No. I, Royal Union. Radiator No. II, Reed, Radiator No. III, Nason. Radiator No. IV, Perfection, with 13 sections.

TABLE III.—RESULTS OF TESTS OF CAMP AND WOODWARD (*Concluded*)

No.		Test No. 7.				Test No. 8.				Test No. 9.			
1	Duration, Hours...	1	1	1	1	1	1	1	1	1	1	1	1
2	Compartment Number	1	2	3	4	1	2	3	4	1	2	3	4
3	Radiator Number	IV	III	II	I	III	IV	II	I	III	IV	II	I
4	Mean Steam Pressure by Gauge	4.08	4.13	4.18	4.13	5.03	5.08	5.13	5.08	4.49	4.54	4.59	4.54
5	Mean Absolute Steam Pressure	18.13	18.18	18.23	18.18	19.30	19.35	19.40	19.35	18.80	18.85	18.90	18.85
6	Temperature Entering Steam	222.8	223.9	223.1	222.9	226.1	226.2	226.3	226.2	224.7	224.8	225.0	224.8
7	Mean Temperature of Compartment	89.8	89.7	89.6	89.4	94.3	94.7	95.2	94.7	94.0	92.9	94.5	94.2
8	Difference of Temperature, Steam and Air	133.0	133.2	133.5	133.5	131.8	131.5	131.1	131.5	130.7	131.9	130.5	130.6
9	Mean Temperature of Condensed Steam	183.7	181.5	186.4	168.0	165.1	167.9	209.5	162.5	173.8	138.0	197.3	152.3
10	Weights of Steam Condensed, pounds	9.45	10.35	10.83	17.33	8.79	8.94	10.94	10.85	9.43	7.30	10.98	10.18
11	Quality or Per Cent of Dry Steam	100.	100.	99.59	92.10	98.97	98.48	99.33	98.78	98.06	97.45	99.42	97.42
12	Total Heat in one pound of Steam supplied, B. T. U.	1149.89	1149.94	1146.05	Water came over with steam.	1141.04	1136.41	1144.59	1139.18	1131.91	1126.12	1145.02	1125.83
13	Total Heat in one pound of Condensed Steam above 32°	152.28	150.06	154.99		133.50	136.32	178.35	130.88	142.27	106.22	166.02	130.61
14	Heat Radiated per lb. of Steam, B. T. U.	997.61	999.88	991.06		1007.54	1000.09	966.24	1008.30	989.64	1019.90	979.00	1005.22
15	Total Heat Radiated per hour, B. T. U	9427.41	10348.76	10733.18		8856.28	8940.80	10570.67	10940.01	9285.15	7342.28	10749.42	10233.14
16	Heat Radiated, per hour and per degree difference of temperature, B. T. U.	70.88	77.69	80.40		67.19	67.99	80.63	83.19	71.04	55.67	82.37	78.35
17	Same, per square foot actual surface	1.420	1.654	1.651		1.431	1.362	1.656	1.693	1.513	1.117	1.691	1.597
18	Same, per square foot rated surface	1.363	1.618	1.546		1.398	1.307	1.550	1.681	1.481	1.071	1.584	1.582

Radiator No. I, Royal Union. Radiator No. II, Reed. Radiator No. III, Nason. Radiator No. IV, Perfection, with 13 sections

being due largely to a change in difference in temperature and also to changes in velocity of air passing over the radiator.

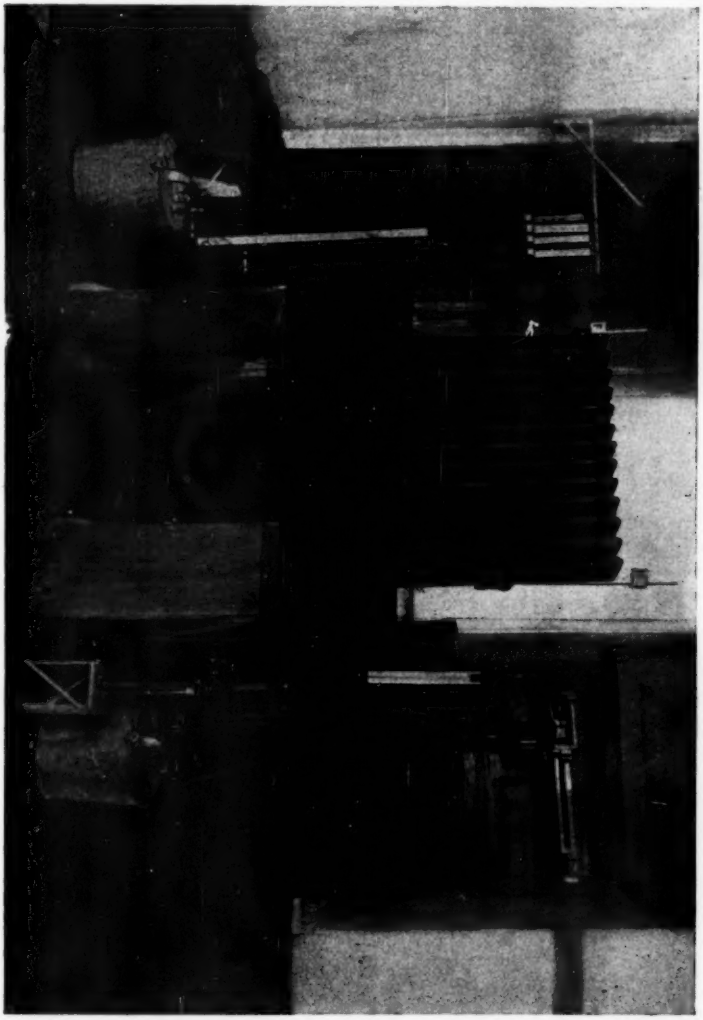

FIG. 11.—THE REED RADIATOR, WITH APPARATUS ATTACHED.

Test by Dunn and Mack.—The final tests on the series of radiators were made by Charles Dunn and William G. Mack under the

supervison of the writer. This test was made under the same general methods as that of Camp and Woodward. The plan adopted by Camp and Woodward was modified in many details, but the

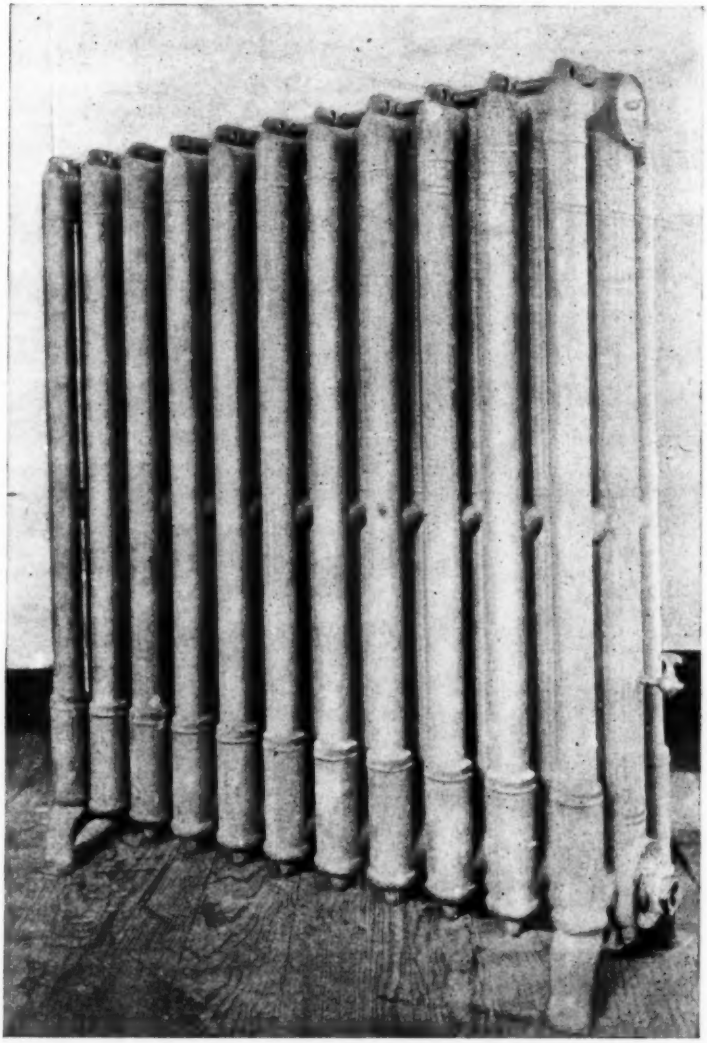

Fig. 12.—THE ROYAL UNION RADIATOR

tests were conducted in the same compartments and in the same general manner. To avoid the difficulty due to the extra loss of heat in the extreme compartments, the testing was all done in the intermediate compartments, using only two radiators at a time. The ceiling over the compartment was reduced in area to about 12 square feet, and the passage for the entering air reduced to 5.1 square feet. These areas were divided by cross strings into small squares, and during the operation of the test anemometer readings were taken to obtain the velocity of the air entering and that discharged. Various thermometers were used to obtain the temperature.

The results of these tests are given in detail with the tables of data accompanying this report. In general, it may be said that the results of the tests made by Dunn and Mack were very satisfactory. The experience of the past two years had served to point out not only the difficulties which were likely to occur, but also methods for remedying these difficulties and for eliminating the errors generally. In the tests made in this last series 14 radiators were tested. Each radiator was tested three times, the first two tests being made with all the windows and doors in the large room surrounding the compartment closed (see Fig. 5), the third test being made with windows and doors open, so as to get as great a movement of the air as possible under the existing conditions. Table IV gives the names and dimensions of the radiators tested ; Table V gives the average results of the various tests. The general conclusions to be drawn from these various tests are in accord with the statements made in the introduction to this article.

With radiators of the same height and same dimensions no difference could be traced, which was due either to material or to thickness. With radiators of the same material and the same height, but of different depths, or with varying numbers of tubes, we find invariably that higher results are obtained from the thinner radiator, or those with the fewest rows of tubes.

With radiators of the same form, but of different heights, the lower the radiator, the more efficient. This was well illustrated in the case of the two forms of Royal Union radiator. In this case the radiator 17 inches high, with practically the same amount of heating surface as another 37 inches high, and of the same cross-section of tube, gave an efficiency about 50 per cent greater than that of the higher radiator.

The amount of heat given off increases very much faster than the difference in temperature between the steam inside and the air outside. This rate of increase is probably substantially the same as

TABLE IV.—RADIATOR TEST, DUNN AND MACK.—TABLE OF DIMENSIONS.

Makers of Radiator.	No.	General Class.	Number of Sections	No. of Tubes in Section.	Height, Inches	Rated Surface Sq. Ft.	Measured Surface, Sq Ft	Weight Pounds.	Volume Cu. Ft.	Wt. per Section.
Western Tube Co.	2	Wrought Iron Tubes, with Cross Connections for Hot Water, No. 2.	12	4	32½		41 19	215	0.7105	20 4
" " "	1	Like above, but Steel Tubes, No. 1.	12	4	35		45.13	254	0.7887	21.2
" " "	1	Steel Tubes, not joined at top, Steam Form.	12	4	35		47.24	269	0.7655	22.4
" " "	2	Like above, but Wrought Iron.	12	4	32½		43.33	247	0.7145	20.5
H. B. Smith Co.		Cast Iron, Pipe Form, Royal Union.	11	3	37		49.12	370	1.47	33 6
" " "		Same as above, but Lower Pattern.	26	3	17		52.81	425	1.4286	25.0
Michigan Radiator Co		Perfection Steam Radiator, (Section 35 Inches by 7½ Inches	12	2	37¼	48	48.17	322	1.526	26.7
" " "		Perfection Steam Radiator, (Section 35 Inches by 7½ Inches)	10	2	37¾	40	40.2	253	1.2717	25.3
A. A. Griffing Iron Co		Bundy Elite, Cast Iron, 3 Tubes Joined.	9	3	36		41.8	320	0.943	35.5
" " " "		" Steam.	16	1	37		45.11	330	0.8829	20.6
Pierce Steam Heating Co		Large Cast Iron Sections, National Steam	10	2	38	40	39.74	273	1.2278	27.3
" " " "		Ideal Steam, Cast Iron.	10	2	38	40	39.43	279	1.2605	27.9
		Ideal Hot Water	10	2	38	40	39.32	300	1.465	30.0
H. B. Smith Co.		Whittier Extended Surface, Cast Iron.	3	1	30		38.65	282	0.6178	
		Projected Surface of above.					17.70			

TABLE V—RESULTS OF TESTS MADE BY DUNN AND MACK.

Radiator.	Western Hot Water. No. 1, Steel			Western Hot Water. No. 2, W. I.			Western Steam. No. 1, Steel.			Western Steam. No. 2, W. I.			Royal Union. 37 inches high.		
Number of Test	4	5	6	1	2	3	7	8	9	10	11	12	13	14	15
Mean Steam Pressure	3.52	3.33	4.19	3.67	3.77	3.34	4.34	4.36	3.72	4.14	4.04	3.82	3 34	3.61	3.19
Absolute Steam Pressure	17.78	19.45	18.35	17.99	18.09	17.52	18.36	18.48	17.65	18.3	18.2	17.9	17.4	17.7	17.2
Temperature of entering steam	221.8	220.8	223.4	222.4	222.7	221.0	223.4	223.8	221.4	223.3	223.1	222.1	221.0	221.5	221.0
Mean temperature of compartment	75.5	73.1	63.9	89.2	92.6	93.4	78.8	80.8	66.4	78.5	74.9	63.6	71.2	84.0	64.2
Difference of temperature	146.2	147.6	159.5	133.2	130.1	127.6	144.6	143.0	155.0	144.8	148.2	158.5	150.0	137.5	157.0
Mean temperature of condensed steam	171.2	184.6	180.7	176.8	171.3	170.4	191.9	186.8	188.6	208 0	188.0	202.0	158.5	173.6	182.9
Weight of condensed steam, pounds	21.06	23.43	25.98	22.25	21.18	22.0	22.18	20.43	23.43	22.9	21 7	25 2	25.7	24.4	29.5
Quality of steam, per cent	100	100	100	99.8	99.8	100	99	100	98.8	100	100	100	100	100	98.9
Heat absorbed per pound of steam B T. U	1009	995	993	1002	1007	1030	980	993	980	972	998	978	1020	1000	986
Total heat per hour, B. T. U	10625	10933	14077	8921	8429	9060	10868	10154	11479	11407	10815	12452	13099	12288	14535
Total per degree difference of temperature per hour, B T. U	72.6	80 8	88.2	67.0	64 5	65.9	75.12	71.0	73.4	78.7	73.0	77.9	87.47	89.35	92.7
Same per square foot actual surface	1.60	1.79	1 95	1.62	1.56	1.60	1.59	1.50	1.55	1.81	1 68	1.79	1.78	1.88	1.88
Cubic feet of air passing through compartment per hour	....	....	....	....	....	....	....	....	....	....	...	....	21436	20872	38482
Temperature of air entering	....	....	....	..	.	....	. ..	...	....	....	....	....	60.7	73.0	54.1
Temperature of air leaving	....	....	....	....	....	...	....	....	....	. ..	....	....	90.0	96.0	82 8

TABLE V.—RESULTS OF TESTS MADE BY DUNN AND MACK (*Continued*).

Radiator.	Royal Union.			Perfection, Steam.						National.			Ideal, Steam.		
	17 inches high.			12 Sections, Wt., per Sec. 26?7.			10 Sections, Wt., per Sec. 25.3.			10 Sections.			10 Sections.		
Number of Test	34	35	36	16	17	18	22	23	24	25	26	27	28	29	30
Mean Steam Pressure.....	4.07	3.61	3.43	3 53	3.86	3.39	2.53	2.51	3.75	3.46	3.71	3.68	3.91	3.41	3.67
Absolute Steam Pressure...	18 4	17.9	17.6	17.6	18.2	17.7	16.7	13.7	17.9	17.6	17.7	17.8	16.0	17.6	17.9
Temperature of entering steam.....	223.5	222.1	221.4	221.0	223 0	222.0	218.1	218.5	222.1	221.2	221.7	221.9	222.4	221.1	222.0
Mean tem, erature of compartment.....	70.5	69.9	61.8	74.3	66.7	55 1	67 1	73.1	54.5	67.3	69.5	62.1	67.1	62.4	66.9
Difference of temperature.	153.0	152.2	159.6	147.0	156.3	166.5	151.5	145.4	165.6	154.0	153 0	160.0	155.3	158.7	155.1
Mean temperature of condensed steam.....	183.4	182.6	188.0	190.5	201.8	197.8	200.0	178.0	205.4	192.0	202 0	204.0	167.7	181.0	201.0
Weight of condensed steam, pounds	43.7	39 9	50.4	25.7	24.9	30.98	19.8	17.7	25.6	21.6	20.9	22.9	21.0	21.3	21.8
Quality of steam, per cent..	93.2	95.2	91.2	98.9	98.4	100	100	100	100	100	100	100	99 6	100	100
Heat absorbed per pound of steam, B. T. U	933	954	907	978.7	963.2	982.0	979 0	1001.0	976.0	982.0	979 0	977 0	1009.0	1001.0	980.0
Total heat per hour B. T. U.	20399	19069	23217	12563	13002	15221	9689	9849	11503	10026	10249	11204	10633	10655	10682
Total per degree difference of temperature per hour, B. T. U..... ...	130 0	125.0	145 0	85.48	76.78	91.36	63.93	60.3	68.6	66.55	67 36	70.09	68.4	67.1	68 9
Same per square foot of actual surface.....	2.46	2.37	2.75	1.77	1 59	1.89	1.59	1.51	1.71	1.67	1.69	1.76	1.73	1.70	1.74
Cubic feet of air passing through compartment per hour.....	38961	42600	40100	....	14650	25867	18823	19407	20619	21588	23406	25594	28975	22109	22096
Temperature of air entering	58.4	57.9	46.8	....	54.5	43.5	58.2	65.3	41.2	58.8	61.1	47.4	47.4	52.8	57.5
Temperature of air leaving.	84.2	83.7	76.2	....	87.5	74.7	68.6	94.4	71.0	88.8	91.1	82.5	82.5	84.0	87.5

TABLE V.—RESULTS OF TESTS MADE BY DUNN AND MACK (*Concluded*).

Radiator.	Ideal Hot Water. 10 Sections.			Bundy Elite. 9 Sections.			Bundy Steam. 1 Row, 16 Sections.			Whittier. Extended Surface.		
Number of Test	31	32	33	19	20	21	37	38	39	40	41	42
Mean Steam Pressure	4.01	3.85	3.89	3.41	2.96	2.67	3.73	3.36	3.28	3.7	3.0	1.85
Absolute Steam Pressure	18.2	18.1	18.2	17.7	17.2	16.9	18.0	17.7	17.4	18.0	17.3	16.2
Temperature of Entering Steam	223.0	223.0	223.0	221.5	220.2	219.2	228.6	221.5	221.0	222.0	220.0	217.0
Mean Temperature of Compartment	68.5	55.1	64.5	68.4	68.1	48.1	69.4	67.1	61.4	69.9	56.1	66.1
Difference of Temperature	154.5	167.6	158.4	153.1	157.1	171.1	153.2	154.4	159.4	152.6	164.3	151.0
Mean Temperature Condensed Steam	207.9	202.5	204.2	202.2	183.5	199.0	194.0	194.3	201.0	182.4	176.6	175.3
Weight of Condensed Steam	24.0	27.8	27.2	21.4	22.2	28.98	30.0	27.3	30.9	19.55	20.4	17.9
Quality of Steam	97.3	99.7	95.3	99.3	100	99.5	67.7	86.6	96.2	90.9	96.9	93.9
Heat Absorbed per pound of Steam	948	955	932	971	996	975	677.3	800	940	911	975	946
Total Heat per hour, B. T. U.	11376	13359	13694	11862	11046	13863	12175	14922	14558	8914	9965	8485
Total Heat per degree, difference of temperature, and per hour	74.97	79.1	98.3	77.46	70.3	81.08	79.5	96.6	91.3	58.4	60.6	56.2
Same, per square foot actual surface	1.91	2.01	1.99	1.88	1.71	1.96	1.76	2.14	2.02	1.51	1.56	1.45
Cubic feet of air entering compartment per hour	22492	20887	17350	22512	23870	29122	40269	30302	26806	26683	39683	28170
Temperature of air entering	59.0	37.6	50.6	59.0	50.2	39.6	55.6	53.2	44.9	57.1	40.7	52.8
Temperature of air leaving	89.2	76.3	85.9	87.5	83.3	69.95	81.8	76.9	74.8	77.9	64.9	76.6

found in the experiments of Peclet. The final results which are given in Table VI, have been called the coefficients for the radiators, the coefficient being the number of heat units given off per square foot of surface per hour per degree difference in temperature between the steam inside and the air outside. It will be noticed that this coefficient is increased rapidly by an increase in the difference of temperature of the steam and the surrounding air. It is to be noticed further that these coefficients are much smaller than those which might be obtained from single lines of pipe exposed freely to the air. This fact is well brought out by comparing the results of the radiator tests with those of single lines of piping tested under the same conditions as to difference of temperature, and described later in this paper.

It will be noted that, whereas the radiator coefficient for a difference of temperature of 150 degrees is usually about 1.6 B. T. U., the coefficient from 2-inch horizontal pipe with the same difference in temperature is 3.8, and for a 1-inch pipe, under the same conditions, is 5.7 B. T. U. These figures emphasize the fact that the arrangement of tubes, form of section, and amount of air space in the modern radiator, is capable of much modification, which may be such as to greatly improve the efficiency of the radiator.

The results would also indicate that extended surface, when applied to radiators of the same form or class, increases the total heat discharged to a great extent. Reckoned, however, from the total extended surface, the coefficient for such radiators is very low. Indeed, compared with some other forms of radiators without extended surface, their efficiency is much less. Even reckoned by the heat discharged per pound of weight of cast iron, it is doubtful if the extended surface radiator shows any advantage over similar forms of radiators with plain surface. I am not, however, positive regarding this point.

Radiators of very great dissimilarity of form and of unequal dimensions cannot be compared with safety. The efficiency of a radiator is much affected by the arrangement of tubes ; tubes are often arranged in such a manner as to mutually intercept the greater portion of the radiant heat, and in such cases the efficiency will be low. Radiators with one row of tubes are much superior to those of the same kind with two or more rows of tubes, and makers sometimes select such forms as representations in a test. The reason for this is not difficult to explain, and is evident to any one who studies radiator construction. The fact that lower radiators are more efficient than taller ones would indicate that the tubes in the high radiators were too closely spaced, and that the air in its passage

upward reaches nearly its maximum temperature in a short distance, and from that point onward absorbs but little heat. For a forced circulation of air these conclusions will no longer hold, as the conditions are changed to a great extent. From the tests made with different velocities of air passing over a horizontal pipe

TABLE VI.—GENERAL SUMMARY OF ALL THE TESTS.

Name or Kind of Radiator.	Dimensions.				Tests of Kelsey & Jackson.		Tests of Camp & Woodward.		Tests by Dunn & Mack.	
	No. Sections.	Rows of Tubes	Surface, Sq. Ft.	Height, Inches.	Difference of Temperature, Deg. Fah.	Coefficient.	Difference of Temperature, Deg. Fah.	Coefficient.	Difference of Temperature, Deg. Fah	Coefficient.
W. I. Vertical Pipes.	12	4	53.6	36	94.	0.62				
W. I. Vertical Pipes, Nason	16	3	47.94	36	90.	0.669	145.	1.70		
					146.6	1.83	144.	1.69		
							133.	1.62		
W. I. Hot Water, Western No. 2.	12	4	41.19	32½					133.2	1.62
									130.1	1.56
									137.6	1.60
W. I. Steam, Western No. 2	12	4	43 33	32½					144.8	1.81
									148.2	1.68
									158.5	1.79
Steel, Hot Water, Western No. 1.	12	4	45.13	35					146.2	1.60
									147.6	1.79
									159.5	1.95
Steel, Steam, Western No. 1	12	4	47.24	35					144.6	1.59
									143.0	1.50
									155.0	1.55
Cast Iron, Bundy	16	1	45.11	37					153.2	1.76
									154.4	2.14
" " "	10	3	79.	37	149.	1.64			159.4	2.02
" " Bundy Elite	9	3	41.8	36					153.1	1.88
									157.1	1.71
									171.1	1.96
" " "										
" " Reed	13	1	48.7				151.	1.688		
							147.	1.627		
							136.	1.523		
" " Royal Union	11	3	49.12	37	151.	2.08	151.	1.688	150.	1.78
							139.	1.565	137.5	1.88
							130.	1.582	157.	1.88
" " " "	26	3	52.81	17					153.	2.46
									152.	2.37
									159.	2 75
" " Perfection Steam	13	2	49.9		91.	0.63	147.8	1.456		
							147.	1.374		
							144.	1.433		
" " " "	12	2	48.17	37¼					147.0	1.77
									156.3	1.59
									166.5	1.89
" " " "	10	2	40.2	37¾					151.5	1.59
									145.4	1.51
									165.6	1.71

TABLE VI.—GENERAL SUMMARY OF ALL THE TESTS (*Continued*).

Name or Kind of Radiator.	Dimensions.				Tests of Kelsey & Jackson.		Tests of Camp & Woodward		Tests of Dunn & Mack.	
	No. Sections	Rows of Tubes	Surface, Sq. Ft.	Height, Inches	Difference of Temperature, Deg. Fah.	Coefficient.	Difference of Temperature, Deg. Fah.	Coefficient.	Difference of Temperature. Deg. Fah	Coefficient.
Cast Iron, Perfection Hot Water	12	2	48.	37	89.	.664	.....	.....	....	....
					150.	1.55				
" " Ideal Steam.....	10	2	40.	38	.....	.....	.....	.....	155.3	1.73
									158.7	1.70
									155.1	1.74
" " " Hot Water....	10	2	40.	38	140.	1.61			154.5	1.91
									167.6	2.01
									158.4	1.99
" " National Steam	10	2	40.	38	.....	....	.....	.....	154.	1.67
									153.	1.69
									160.	1.76
" " Whittier Ex. Surface.	3	1	38.65	30	142.	1.13			152.6	1.51
									164.3	1.56
" " Michigan Indirect...	:	.	58.2	....	91.	.434			151.0	1.45
					140.	1.27				

the amount of heat absorbed seems very nearly directly proportional to the velocity of air, and three or four times as much as in still air.

This would indicate what is quite well known, that the increase in coefficient of the heating system might, in the case of forced circulation, be sufficient to more than counterbalance losses due to introducing large quantities of air directly into the room. Table VII gives the results of the tests which have been previously described.

TABLE VII.—RESULTS OF TESTS MADE BY DUNN AND MACK—HORIZONTAL PIPE.

	Two-inch Pipe.		Two-inch Pipe.		Two-inch Pipe.		Two-inch Pipe.		One-inch Pipe.		One-inch Pipe.		One-inch Pipe.		One-inch Pipe		Two inch Pipe with blower.
Number of Test.	1	2	3	4	5	6	7	8	10	11	12	13	14	17	15	16	18
Mean Steam Pressure.....	5.54	5.46	13.6	13.7	27 1	28.1	46.3	47.8	12.7	13.0	5.54	5.31	13.6	14.4	27.5	26 9	4.45
Absolute Steam Pressure...	19.83	19.61	27.82	27.92	41.2	42 32	60.51	62.02	26.84	27.11	19.61	19.38	27 89	28.67	41.79	41.17	18.63
Temperature of steam entering.....	227.39	226.9	246.0	246.21	268.9	270.59	293.13	294.93	244.0	244.55	236.9	226.28	246.14	247.71	269.8	269 49	224.22
Mean temperature of compartment.....	69.30	73.7	78.9	79.1	78.9	71.6	78.5	83.1	75.5	77.1	71.6	77.7	87.7	82.1	96.9	77.5	100.5
Difference of temperature between steam and air...	158.09	153.2	167.1	167.11	190.0	198.99	214.63	211.83	168.5	167.45	155.3	148.58	158.44	165.61	172.9	191.99	123.72
Mean temperature of condensed steam.....	173.6	155.8	150.4	192.8	230.2	232.0	276.1	277.3	225.1	228.5	201.6	208.2	233.0	232.6	257.8	257.0	210.2
Weight of condensed steam in pounds.....	11.43	9.68	12.25	12.68	17.0	19.18	21 6	21.18	11.25	11.0	9.75	9.75	11.0	10.5	12.0	12.9	8.68
Quality of steam.....	95.27	96.31	99.84	97.18	98.50	97.33	98.36	99.05	97 66	98.23	96.98	97.89	100	100	100	100	92.81
Heat given out per pound of steam in B. T. U.....	962.11	991.82	1036.77	969.05	948.89	918.29	910.34	916.20	940.2	942 19	952.00	936.84	954.71	955.69	936.78	927.52	900.76
Total heat per hour, B. T. U.	549.80	4800.0	6350.1	6143.7	8065.1	8806.4	9558.6	9702.6	5288.6	5182.0	4651.7	4664.6	5250.9	5017.4	5620.6	6056.4	7818.6
Total heat, degree difference of temperature per hour B. T. U.....	34.78	31.33	38.00	36 76	42.44	44.25	44.53	45.80	31.38	30.94	29.25	31.39	33.14	30.29	32.52	31.54	63.19
Same per square foot actual surface	3.479	3.135	3.802	3.678	4.247	4.427	4.458	4.582	5.648	5.569	5.39	5.649	5.965	5.452	5.89	5.676	6.322

The velocity of air in test 18 was 9.87 feet per second.

TABLE VII.—RESULTS OF TESTS MADE BY DUNN AND MACK—HORIZONTAL PIPE (*Concluded*).

	Two-inch Pipe with blower.	Two-inch Pipe with blower.		Two-inch Pipe with blower.		Two-inch Pipe with blower.		Two-inch Pipe with blower.		Two-inch Pipe with blower		Two-inch Pipe with blower.		Two-inch Pipe with blower		Two-inch Pipe with blower.	
Number of Test	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Mean Steam Pressure.....	5.09	5.38	5.86	5.27	5.15	12.48	13.7	12.1	12.25	13.73	13.55	25.35	27.1	27.54	28.21	27.1	26.7
Absolute Steam Preasure...	19.28	19.62	20.05	19.47	19.35	26.67	27.63	26.03	26.18	27.71	27.53	39.46	41.21	41.65	42.32	41.22	40.82
Temperature of entering steam.....	226.0	226.93	228.09	226.47	226.20	243.64	245.78	242.29	242.50	245.78	245.42	266.35	268.92	269.50	270.58	268.98	268.39
Mean temperature in compartment.....	105.7	113 25	114.65	107.15	110.0	109.35	113.05	114.45	116.75	119 85	122.55	109.3	110.65	115.8	117.3	122 3	121.2
Difference of Temperature, between steam and air....	120 3	113.68	113.44	119.32	116.2	134.29	132.73	127.84	125.75	125.93	122.87	157.05	158.27	153.7	153.28	146.68	147.19
Mean temperature of condensed steam	216.0	210.9	216.4	211.1	209.1	229.7	229.7	232.5	232.2	235.0	234.6	250.6	254.8	254.5	257.6	254.9	255.3
Weight of condensed steam, pounds.....	7.93	5.18	5.25	6.75	6.56	7.75	7.25	7.25	7.06	6.0	6.43	9.48	10.0	8.93	8.88	6.63	7.25
Quality of steam.....	100	96.88	98.43	99.3	99.18	100	99.19	96.76	96.76	100	100	99.48	99.44	98 13	99.60	98.75	99.62
Heat given out per pound of steam, B. T. U.....	965.93	941.62	951.16	964.38	966.31	958.39	950.48	923.68	924.09	952.67	952.97	938.25	934.87	922.86	933.52	928.0	935.52
Total heat given out per hour, B. T. U.....	7659.6	4877.6	4993.6	6509.6	6339.0	7427.5	6891.0	6696.7	6524.0	5716.0	6127.6	8894.6	9348.7	8241.1	8289.6	6152.7	6782.4
Total heat degree difference of temperature per hour, B. T. U...	63.67	42.90	47.14	54.56	54.55	55.30	51.91	52.38	51.86	45.25	49.86	56.63	59.06	53.61	54 08	41.93	46.08
Same per square foot actual surface..... - -	6.370	4.292	4.716	5.459	5.458	5.533	5.194	5.241	5.189	4.528	4.989	5.666	5.909	5.364	5.411	4.196	4.611
Velocity of air, feet per second.....	8 57	4.39	4.283	6.92	5.57	6.47	6.15	5.784	5.62	3.674	3.319	7.64	7.34	6.29	6 23	3.901	3.567

TABLE VIII.—SUMMARY FOR HEAT TRANSMISSION, STILL AIR.

	Steam pressure by Gauge.	Average difference of temperature of steam and air of room.	Heat Transmission in B. T. U. per square foot per hour for each degree of Temperature.
2-in. pipe.	5.50	155.64	3.307
	13.65	167.10	3.745
	27.60	194.49	4.337
	47.05	213.23	4.518
1-in. pipe.	5.43	151.94	5.519
	13.43	165.0	5.658
	27.20	182.45	5.783

TABLE IX.—SUMMARY OF RESULTS.—TEST OF STEAM PIPE WITH BLOWER.

Steam Pressure by Gauge.	Average Difference of Temperature of Steam and Air of Room.	Velocity of Air Passing over Pipe, feet per second.	Heat Transmission in B T. U. per square foot per hour for each Degree of Temperature.
4.45	123.72	9.870	6.322
5.09	120.30	8.570	6.370
5.38	113.68	4.396	4.292
5.86	113.44	4.283	4 716
5.27	119.32	6.920	5.458
5.15	116.20	5.570	5.458
5.20	117.77		Average.
12.48	134 29	6.47	5.533
13.70	132.73	6.15	5.194
12.10	127.84	5.78	5.241
12.25	125.75	5.62	5.189
13.73	125.93	3.674	4.528
13.55	122.87	3.319	4.986
12.97	128.24		Average.
25.35	157.05	7.64	5.666
27.10	158.27	7.34	5.909
27.54	153.70	6.29	5.364
28.21	153.28	6.23	5.411
27.10	146.68	3.901	4.196
26.70	147.19	3.567	4.611
26.97	152.69		Average.

Tests of Single Line of Piping.—These tests have already been referred to, and were made by Messrs. Dunn and Mack under the direction of the author. They are of interest because the conditions could be varied to a greater extent than was possible with radiators of commercial form. The tests undertaken utilize a length of pipe of 16 feet, $1\frac{1}{4}$ inches, arranged in such a way that the water of condensation could be accurately weighed. The arrangement for supplying steam, and for measuring the surround-

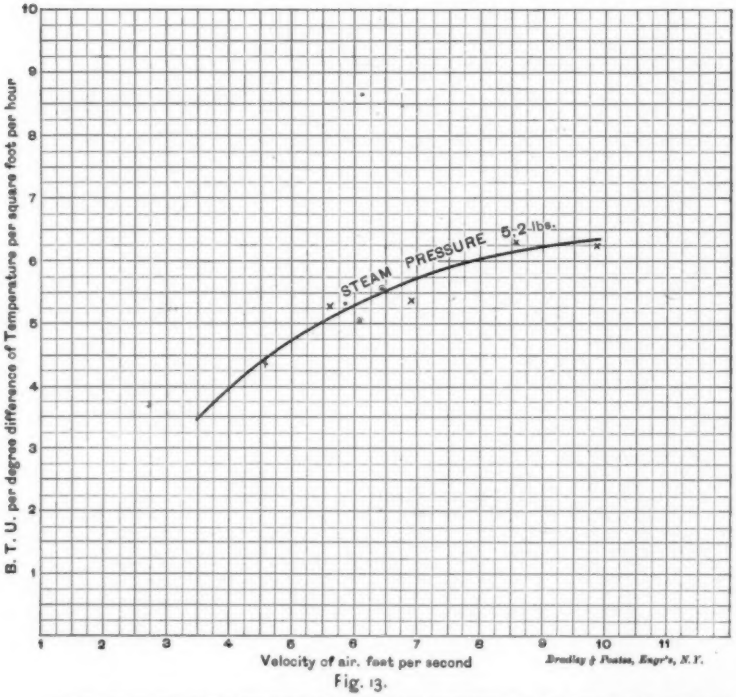
B. T. U. per degree difference of Temperature per square foot per hour
STEAM PRESSURE 5.2 lbs.
Velocity of air, feet per second
Bradley & Foster, Engr's, N.Y.

Fig. 13.

CURVE SHOWING INCREASE IN REAL TRANSMISSION IN STILL AIR DUE TO INCREASE OF DIFFERENCE OF TEMPERATURE BY USE OF HIGHER PRESSURES OF STEAM.

ing temperature, was essentially as described for the radiator tests. These tests were made in still air under different conditions of steam pressure with 2-inch and 1-inch pipe. The 2-inch pipe was also surrounded with a thin casing, and air of different velocities was forced through by a blower. The results are given in Tables VIII and IX. They show for the 2-inch pipe that, with still air, the

coefficient for heat transmission varies from 3.3, with 5 pounds steam pressure, to 4.52 for 47 pounds steam pressure.

These results are shown graphically on the accompanying diagram, Fig. 13. With the same pipe under a forced blast, we have as shown in the diagram, Fig. 14, the coefficients varying from 4.5, with a velocity of air of 4.4 feet per second, to 6.4 with a velocity of air of 9.2 per second, when the steam pressure was 5 pounds. With a higher steam pressure the results were still greater, and are

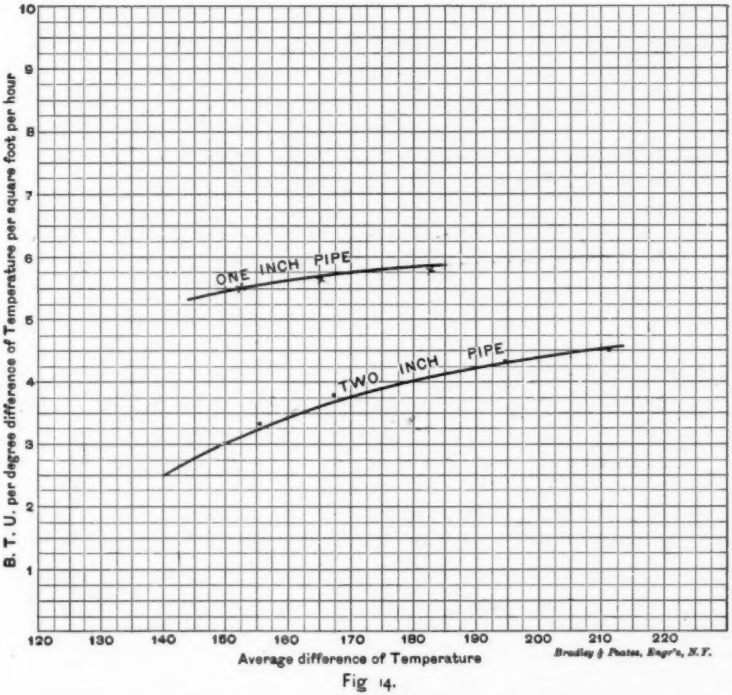

Fig 14.

CURVE SHOWING INCREASE IN HEAT TRANSMISSION DUE TO INCREASE IN VELOCITY OF AIR.

shown fully in the accompanying diagrams and tables of results.

With 1-inch pipe the results per square foot of surface are considerably higher under the same conditions than those given for the 2-inch pipe. The average results for the 1-inch pipe are fully shown in Table IX and Fig. 13.

DISCUSSION.

Mr. Barron :—I prepared a few remarks for the discussion of this paper, but I approach it now with fear and trembling. I am afraid that I may say something that would be offensive to others. In the comparison of different devices Prof. Carpenter has just done a little you know—he has mentioned the names of radiators, and of course I know how exceedingly careful we have to be in mentioning any radiator. I have no desire to place one radiator above another, because I believe that the difference between the poorest and the best is not very great.

Mr. Barron then read the following:

I believe it is generally known that extended surface and flue radiators are not effective at very low pressures, for the same reasons that such radiators are not effective for low temperature hot water heating. It requires a temperature of from 10 to 15 pounds, i.e., a temperature corresponding to that pressure, to make such radiators give even fair results.

I am sorry Prof. Carpenter has not included in his tests the various flue radiators such as the Joy and Porter. For myself, I have always regarded the flue principle as decidedly wrong, except, perhaps, for direct-indirect, but I have also always regarded such radiators as the Elite, Standard, and Royal Union of the vertical three-bar or three-pipe class as very inefficient, particularly at ordinary low pressures; but I see by Mr. Carpenter's tests that I have been mistaken. I submit a table* herewith of various radiators and the way I regard them. This is merely a personal estimate and does not claim to be even nearly correct; it is simply an expression of personal views, and the usual personal equation for error must be applied to it. If each of the persons here made a table based on their experience, they would all differ, and the average of such tables might differ decidedly from this one.

That my estimate of the efficiency of radiators varies extremely from Prof. Carpenter's is to be expected ; we are all apt to error —our cherished views are generally the ones that are wrong. I am inclined to think that a great many of those interested in radiators will continue for some time to depend on practical judgment and remain very skeptical about the value of Prof. Carpenter's co-efficients, although they cannot doubt for a moment the perfectly fair manner in which Prof. Carpenter has reached his

*The table given by Mr. Barron was presented to illustrate the fact that the difference between radiators of the highest and the lowest efficiency was small, being only about 10 per cent.

conclusions, or the ability and painstaking labor he has put into this paper. Prof. Carpenter, I think, shows that it is almost impossible to make a satisfactory radiator test. The fact is, we cannot place radiators under actual working conditions and test them ; by that I mean radiators should be on the floor, and not standing four feet above it in the center of a room.

Mr. Harding :—Mr. Barron suggests a matter with respect to which I differ with him in opinion. He says that he does not believe in the flue radiator and that the exposed surface radiator is the more effective. Prof. Carpenter shows that in radiators of the same height and same dimensions no difference could be traced which was due either to material or thickness. You find invariably that higher results are obtained from those with the fewest rows of tubes. Now, if a radiator which has the fewest rows of tubes is the most effective, why is not a flue radiator which has four rows of tubes more effective than a four row tube radiator that has not the flues? According to a statement by Sir William Thompson (I think it is in the Encyclopædia Britannica), a red hot stove, or a stove heated to a temperature of 1,200 odd degrees, gives off its heat in the two methods of radiation and convection in the following proportions : 92 per cent of the heat which is given off from that high temperature of the stove is by radiation, and only 8 per cent of the heat given off from that stove is by convection or by contact of air. A radiator at a temperature of 160 degrees gives off its heat by radiation and convection in the following relation : 55 per cent of the heat given off is by convection or contact of air, and 45 per cent of the heat given off is by radiation. Now, when the amount of heat given off at the temperature of 160 degrees, which is not very far from 212 (we will say at half and half at 212), why is not a flue radiator, the process of heating by which is entirely by convection, that is, in the flues, more effective than a four-loop radiator, the inner sections of which are not arranged for the rapid and easy flow of air around those sections ? The term radiator, so far as the inner sections are concerned is a misnomer. The term radiator is a misnomer for any four-loop radiator.

Mr. Jellett :—This is a very interesting question to all of us I think, one that should be very thoroughly discussed, and it should be discussed in an entirely abstract way without any reference to makes, but rather to forms of construction. I have used pretty much all the known forms that are in the market to-day with varying results. My own experience has been that a radiator with a closed base is the least efficient for the reason

that it prevents the rapid circulation of the air. The movement of air in a room caused by heat is, of course, upwards. If the base of the radiator is solid, into which pipes or tubes are screwed, there is no direct vertical movement of the air, and the efficiency of the radiator is lessened thereby. The radiator manufacturers themselves recognize this fact, as you find that all the recent styles of radiators have abandoned the use of the entirely solid base, which was the old form of construction. They are getting into a nipple connection, but they are rounding the base of the radiator beyond the connection, so as to admit of air coming over the joints and passing into the section. They are also opening the section in the middle to admit of any cross movement of air. Now this is a move in the right direction. A step from that is the flue radiator; the first referred to by Mr. Barron was the Joy radiator. Personally I am not a strong believer in the value of extended surface. It acts as a guide or a channel. It does not do very much in the way of heating. But it is useful in so far as it directs the air against the heated surfaces and makes the prime surface more efficient. A step from that has been to the prime surface flue radiator. These radiators I have used with very satisfactory results indeed. It is a radiator that gives the maximum amount of air movement, and the maximum amount of heating surface in direct contact. I have measured the flow of air over such forms of radiators, and I found a velocity of air in some cases 2½ times as great as in the old form of open side radiators, and I have heated a given amount of space in less time due to the rapid movement of the air, the condensation being in proportion. When this form of radiator first came into the market, most of the manufacturers pooh-poohed the idea that such a radiator would ever be efficient or find a market. They have given up that notion. Concerns that told me three years ago that such a radiator was no good are offering it in the market to-day and admit that they are getting good results from it. It takes up less floor space for a given amount of surface. It also can be used with a box base to admit fresh air in hospitals when the walls will not admit of putting in the proper sized flues. Where you can get the needed amount of air into it, it has an advantage in that it can be used under so many varying conditions to give ventilation as well as heat. Another thing I have noted in connection with flue radiators is that when you have reached a given height the temperature of the air does not increase, or increases very slowly. Prof. Carpenter mentions one case of a radiator 17

inches high which gave an efficiency about 50 per cent greater than another radiator 37 inches high. There is little or no gain in temperature beyond 25 inches in height, and what you gain from the use of the higher radiator is simply the contact of the air with the outer surface. The inner flues do not increase in efficiency beyond that point. This fact has been noted by several engineers within the last year or two, and there is a radiator made now which, when it reaches a point 24 to 26 inches above the floor, is open from the side so as to allow the air to leave at that point, the object being, I preseume, that the higher radiators can be manufactured at less cost per square foot, and it is advisable to meet the competition. In taking radiators of this form we want to take into account the conditions under which they are to be used, the question of exposures, and everything of that kind, just the same as in any other form, and consider them entirely on their merits without any reference to prejudice. Of the open form of radiator such as is well known to-day, the radiators from which I have obtained the best results have been those that have given the greatest amount of air space between the sections, either directly, or on the taper form of the section. With a solid number of tubes in a row the middle sections do but very little work. There is no cross movement of air to any extent, and I notice that among some of the radiator manufacturers lately there has been a tendency to take their sections and taper them, or at least make them into a very flat oval form, so as to get a more direct contact with the air. Prof. Carpenter states here that practically air is heated only by convection, i. e., by the rubbing of the particles against some body of a higher temperature than itself. Results have demonstrated that, and taking that statement as correct, an oval form of radiation is fully as effective as any sectional form that I know of. I have put in radiators of the extended surface pattern as against the other forms without any increase in the ratio of surface, and I figured them on the same basis that I would a prime surface radiator of the ordinary construction, and I have obtained fully as good results in every case. I have radiators in use for some seven years now figured on the same rules as the other radiators, and they are rated by competitors as of 30 per cent less efficiency, but the radiators are doing the work to-day and they are doing it with the same amount of pressure of exhaust and low pressure steam through a reducing valve at usually one to two pound pressures. Our practice in Philadelphia on most specifications is to limit the maximum pressure in the main to two pounds. I

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have contracts at the present time where I am limited in my initial pressure to two pounds of steam. I do not expect to use one pound. I should be very much disappointed if I found there was one pound of steam pressure needed on it. Now, under such conditions and knowing the facts from actual practice, I believe in Prof. Carpenter's theory that the contact of air with the radiator is the best method of heating, and that the form of radiator that will bring the most air in contact with that heated surface is the form of radiator that is the most efficient.

Mr. Blackmore :—I have not made any extended notes on this paper. I fully expected that Prof. Carpenter would have been here. I regret that he is not, for there are many questions I would have liked to ask him. There is one statement here in the early part of the paper that touches on a question discussed yesterday, that is the material of which the radiator is made. On the top of page 2 it says, "The first and third resistances are due to change of media, and when the material under consideration is a good conductor constitute the principal portion of the resistance to the passage of heat." He winds up by saying that the only factor that we have to consider is the outside surface because the air takes the heat off more slowly than the iron takes it through. By that he means that the material put on interferes more or less with its efficiency, so that the contention brought out yesterday that the iron made some difference is shown from his experiments to amount to nothing.

There is another point in Table 1 which I think is very important. It will be noticed, if you refer to that, that in transmitting heat from steam to water the ratio of transmission is very high. With a difference of temperature between the two substantially of 25 degrees, 28.8 units pass through. From air to water you will notice the ratio is very low. With the same difference of temperature it is only 1.2. The point I wanted to ask Prof. Carpenter is this, whether the steam and air that were transmitted as agents to heat the water were both under pressure. This is not stated here. In steam he runs up a difference in temperature of 150 degrees.

The President:—Does he not say that the steam was put in at a definite pressure although he does not state what it was?

Mr. Blackmore:—The only point I wanted to bring up is whether the air was under the same pressure as the steam. Practically the condition he speaks of is the condition of the fire transmitting its heat to the water in a boiler. The fact I want to establish is this—whether the steam would transmit its heat to the water

more rapidly than the heated air passing through a furnace would transmit its heat to the water of the boiler. The ratio is so great I feel that without additional data I would like to question it. If the professor were here that matter could be brought out. I think you will all agree with me that it is a very important matter, and if there is any one here who can give any light on the subject I would like to hear from him.

Now, on page 5 he says, "Thus the heat transmission through iron, from steam to water, varies from 25 to 75 times as much as that transmitted through the same iron plate from air to water. When the heat was passing from steam to water there was a sensible difference, due to the material and thickness of the plates used, but when passing from air to water this difference wholly disappeared." Now it would appear from this that in the use of a feed water heater to supply a steam boiler, when we are heating the water by steam, that the material of transmission is a very vital factor in the case, but in building our steam boilers or our water heaters, it makes no difference, i. e., as to the thickness of the material of which they are built, so far as the work of transmitting the heat of the fire to the water is concerned. This is what we would gather from the professor's experiments.

In making the radiator tests the professor was very careful to measure the amount of moisture by the calorimeter, but he does not state whether he found the difference varied in the different radiators he was testing. I regret very much that the point cannot be cleared up. The amount of moisture in them might have varied considerably and his method of correcting that moisture would largely determine the value of the experiments. Another point I notice, viz., in every test the professor made the conditions were a little different. I have made some tests of radiators at considerable expense and with a good deal of study, and I found it was utterly impossible to make two tests and get the same results even though they were made within half an hour of each other. The difference would be quite material, and I do not think we can get accurate results unless we make three tests under exactly the same conditions and take the average of those three tests as a standard. Prof. Carpenter seemingly made three tests, but each one was made differently. I would like very much to have seen an average of three tests made under exactly the same conditions in each radiator.

To go over the tables, the question about the quantity of water held by the radiators affecting their value might be disputed because the tests were made by steam. The volume of water that a radiator holds was the subject of contention

yesterday, and if you will notice in the tests made, the radiator which, I think, is the first one mentioned on the list, holds a higher ratio of water than any of the others and apparently it gave a less efficiency. It gave the same efficiency per pound of steam used, but the heat given off per foot of radiation was much less. A three-loop radiator gives the highest rate of efficiency and yet that radiator holds quite as much per square foot of surface as the other one. The one that gave the low rate of efficiency was a two-loop radiator. That which gave the highest ratio of efficiency was a three-loop radiator. The Royal Union radiator apparently gives the highest ratio of efficiency of all the tests. The Royal Union radiator holds more or quite as much as the Michigan radiator. Now, again, we have the Nason radiator, which is the pipe form, holding the minimum quantity of water, giving a less ratio of efficiency than the Royal Union, but a greater ratio of efficiency than the Michigan. I confess I cannot see why this should be, except that the Royal Union radiator is the most open radiator made with the three columns. It makes a great difference whether the three-column radiator is open and freely exposed to the air in comparison with one that is closed and compact. If you look at the various ratios right through, in the last tests made by Dunn and Mack the Michigan radiator takes on a greater ratio of efficiency than in the previous tests made by Camp and Woodward. In testing a radiator of that kind it is so difficult to get accurate results that unless a series of tests are made under exactly the same conditions great errors are likely to occur. But as to a radiator, in the case of the tests made by Camp and Woodward, we can assume that it is right for comparative purposes but not conclusive. It is simply a test of efficiency under the conditions that they adopted. How near they approach to what they would be in actual use we have yet to determine.

As to the flue radiator, I regret that experiments were not made with this class, because it is a question about which I am not quite clear myself. Mr. Harding spoke about the amount of heat given off in the two different ways. We all know that any heated solid body will give off heat by radiation and by contact of air, and as the temperature of the body increases the power for radiation increases and that of the heating by contact of air decreases in proportion. Now, at the temperature of the steam in a radiator, I think it is about half and half. Whether in making a flue radiator the circulation is sufficient to compensate for the loss of radiation which we sacrifice in the flues I am not quite clear about. I have, as Mr. Jellett

said, seen excellent results from flue radiators, and other cases where they have not given satisfaction. I have noticed that the short flue radiators give better results. I find, further, that the larger the flues in those radiators the taller we can make them. The smaller the flues the lower the radiator has to be to get its maximum efficiency. It is a point that we can well afford to discuss because we may affect the efficiency of an apparatus by the style of radiator we use. Under some conditions, where the arrangement of a room is such that a free circulation is likely to occur, the flue radiator will probably give a great ratio of efficiency; if the conditions are against this (which is very often occasioned by the furniture of the room) you will find that a radiator having a large amount of radiating surface will give a greater ratio of efficiency than a flue, so it is impossible to say that any radiator under all conditions will do the best work. The obstructions in a room that attract the radiated heat will prevent the free circulation of air which makes a flue radiator valuable.

There are some other points I would like to touch upon, but possibly they will come in better later on.

Mr. Harding:—I would like to take exception to Mr. Blackmore's last statement that there are not conditions in a room which make a radiator of high radiating efficiency of higher heating efficiency than one of low radiating and high convecting efficiency. The lower the temperature of the heated body the greater the economy of raising the temperature of the room. The effectiveness of a radiator has been referred to as being defined by the amount of steam condensed by the radiator. That is its efficacy in the condensation of steam, it is true, but the real efficacy of a radiator is in the number of degrees by the thermometer to which it will raise the temperature of a room, and if the heating body is heating by radiation, there is a very large proportion of that radiant heat which condenses steam which does not raise the temperature of the room. The heat by conduction through air is almost infinitesimal. It cannot be measured. Heat by contact with air is the principal form of heating that we get. It is very true that the rays of heat which proceed from the radiant body will raise the temperature of the object with which they come in contact, and the walls, furniture, and hangings of a room will receive more or less of that heat, and the air in contact with those various things will obtain an increase of temperature. But the walls and windows transmit that heat of radiation out doors and every ray of heat that leaves a radiator and goes to the outer air heats nothing at all, and there are just as many heat units

pro rata given off by radiation as by convection I return to the position that I have taken and I say that the lower the temperature of the radiant body the less amount of steam will be required to raise any number of cubic feet of air a given number of degrees of temperature Fahrenheit, and that every pound of pressure which is put on to a steam plant to obtain the amount of temperature required in the various rooms of the building is a loss, and that every pound which can be subtracted from the initial pressure of the heating plant will reduce the temperature of the radiant body and will increase the value of the steam in heating the air of the room.

Mr. Quay :—I do not know that I can add anything to what has been said. I was quite interested in the talk in regard to flue radiators, also three column radiators, and the single row, or at least as near that as you can get. We find that Prof. Carpenter has brought out very nicely in his paper the advantage of heating by convection. There is one advantage, I think, which was mentioned this morning, that the circulation of the air in a room is a very important matter, and if you have the right kind of radiation I think this will help also in that regard. It was also noted in Prof. Carpenter's paper that air passing over a radiator rapidly has an effect on the heating as well as on the efficiency of the radiation, and I was thinking in regard to specifying a certain amount of radiation in different rooms under different conditions, if we specify that we need a certain number of square feet of radiation we should take into consideration the style of radiation, the height, and all these questions that have been discussed in Prof. Carpenter's paper. If we merely state that there is to be a certain number of square feet of radiation without stating what style—I do not mean whose make, but I mean the style of radiation, and the height of the radiation and whether we are going to have a single row, two row, or three or four row radiators. If we do not go any further than stating the number of square feet of radiation we will surely make a mistake. I would like to hear these three or four points discussed quite fully, so that we can have all the information we can get on this line.

Mr. Wilson :—Speaking of the matter of flue radiation we used about 30,000 feet last year and have used the majority for water. Flue radiation is not considered as efficient in water as it is in steam. At the same time the results I derived seemed very satisfactory and the style of radiation that I have used is a closed circulation for about two feet and open beyond that. I have

not found any difficulty in using the usual formulas. In fact, I found an increase in a great many instances owing to the high velocity of air. I have not taken the velocity, but there are some members here who have taken the velocity and I should like to hear their experience. Practical experience goes for more than theory. My experience with the flue radiators has been very satisfactory. I think they are fully as efficient, and under some circumstances I think they are more efficient. Take a certain room which has the maximum of cooling surface, that is glass and exposed wall ; there I think the flue radiator is more efficient than the ordinary type.

The Chairman (Mr. Onderdonk) :—I would ask if any members have made any experiments on velocities. Has Mr. Jellet made any experiments ?

Mr. Jellett : I have tested a number of radiators, flues with extended surface and flues with prime surface. I find that, on an average, with flue radiators I can get from two to two and a half times the velocity that I can get with any open form of radiator which I have tested. I have gotten velocities of 166 to 180 feet with the flue radiator. I have never averaged more than 70 or 72 with the ordinary form of radiator, and with the box or solid base radiator less than that. The last tests I made were on prime surface flues and that gave me velocity up to 170 feet, the radiator being 80 feet distant from the boiler and the pipes uncovered. That was done with a radiator 25 inches in height. On the ordinary flue construction, after you get beyond 25 inches in height you will find that the velocity does not increase in proportion to the height, neither does the temperature. There is no particular advantage, so far as moving the air or increasing the temperature of the air in the flues themselves, in the higher radiator from, say 25 inches. The air will come in at a fixed temperature and go out at a fixed temperature. In certain makes of radiators they have undertaken to overcome this by opening the side of the flue above that height, so as to allow the air coming up the flue to leave the radiator at the side and give the benefit of any cross-currents of air that may be created above that level. The fact has been known to a number of engineers that flue radiators from 36, 38, and up to 45 inches gain nothing particularly in the temperature. The tests of radiators were made with a closed base and the air-box. I have taken air in at a temperature ten degrees above zero and measured it six inches above the top of the radiator, the thermometer at that point showing 180 and 182 degrees F. I have dropped the ther-

mometer into the flue of the radiator, not coming in contact with the iron, and got a temperature of 203 degrees in the flue. You cannot get that in any form of an open radiator, because the side movement of air prevents your getting that efficiency.

Mr. Hopkins :—What was the proportion of air supplied per square foot of surface to the interior ?

Mr. Jellett :—The sections 25 inches in height would average about 4½ feet of surface, and the air-space at the base of the section would be about nine inches, not counting the outer formation, which would be what I call direct radiant heat outside the line of the first series of flues. Take a section eight or nine inches across, only 6½ or seven of that is actual flue. The rest of that is the projection of the section, which would correspond with the ordinary direct radiator.

Mr. Hopkins :—Yes, but on those radiators connected in the center with nipples there is a large part of the area that is obstructed, so that the only area you can count that gives an air supply to that flue is the actual opening through which the air can pass at its smallest point.

Mr. Jellett :—Not necessarily, because the form of the connection is round. The section itself hangs below. If you take a section of it you will find that the nipple connection is up some distance in the section.

Mr. Hopkins :—That I am not disputing. What I was trying to get at was the actual cross-sectional area of the air supplied to that surface at its smallest point.

Mr. Jellett :—It would be, as I say, about eight square inches ; five feet of surface in the section, but not more than 2¾ in the flues.

Mr. Hopkins :—That is far in excess of anything I have ever measured. Most of these radiators only have about a half inch of air supply per square foot of interior surface. The result is, in my opinion, that there cannot be sufficient air delivered to the interior surfaces to get their best effect. Take it in the ordinary indirect steam heating work ; the rule of thumb of the ordinary fitter has been an inch and a half of cold air supply to a foot of surface, something like that, and we have been told by these rule-of-thumb people that if you gave the indirect a smaller supply of air that you might just as well have less surface and if that general rule or practice is applied, why it follows, if you have, say, 10 square feet of surface in the flues of a vertical flue radiator and are only giving five-inch area of air supply to it, that the ten feet of surface will not do as much work, will not heat as much air as though you had ten square inches supplying it.

I think when we come to take the broad position that a vertical flue radiator ceases to possess any particular value that has the flue surfaces themselves above 25 inches, that it is not correct. We should say that there is an air supply to the surface and a radiator 25 inches high. If we increase the height of that radiator we should increase the area of the air supplied to the additional surface, and then I think we would get approximately the same effect foot per foot.

Mr. Onderdonk :—Mr. Jellett says he has made tests of the efficiency in the circulation of air in the flues of a vertical flue radiator. I made some long ago, but I cannot quote them from memory now. I can give you, however, a little experience that took place two or three days ago. There was a building, eight or ten stories high, that had been heated with vertical flue radiators. The stories were very similar with the exception that in one story the windows were quite low, but there were not so many of them and the radiators of necessity were set under the windows, and on account of being set under the windows could not be more than 25 inches high. The apparatus was put in operation and all of the rooms in the building heated to a satisfactory degree at one pound pressure, except this one room. I measured the rooms carefully and found that the proportions of glass and wall surface, and also the proportions of cubic contents were identically the same. But this room with low radiators in did not appear to heat as well as with the rooms with the high radiators in. I then took a thermometer, which is often my face, and held it over the radiators, and thought that I discerned a much higher temperature on the 36-inch high radiators than on the 25-inch, although I did not make a test with an ordinary thermometer. But it resulted in my recommending that the room with the low radiators have increased surface put in. It certainly appears to me that within certain just limitations the air ought to get hotter in passing over more heated surface. I have found that in the force system, after we have reached that limit, if we blow it over much more pipe, it does not seem to heat it materially hotter. But I do not think the limit is reached at all in the vertical flue radiator at 25 inches I think that the air will be hotter, coming from a flue 36 inches long than from a flue 25 inches long.

VI.

A SHORT TALK ON THE CONSTRUCTION OF HOT WATER RADIATORS.

BY J. J. WILSON, TROY, N. Y.

(Member of the Society.)

My only apology for inflicting this communication upon you is a desire to offer for your consideration a few suggestions of importance relating to the construction of radiators for hot water heating. It has been an idea with many engaged in the heating line that it is necessary to purchase a high-priced radiator in order to have them prove satisfactory. This, however, has not been my experience. The shape of numerous high-priced radiators is such that, while suitable for steam, they do not represent the best type of radiator for hot water heating. It is a well-known fact among the trade that, owing to the phenomenal increase in this system of heating, many radiators formerly used for steam heating were put upon the market for water without any changes, and in cases where they lacked top connections between the sections they were added, very little thought or attention being given to their internal capacities or outward shapes, and there is no doubt that it has been a detriment, in some instances, to the success of this system of heating, requiring much more fuel to heat certain styles of radiators, owing to their large internal capacities for holding water, and entailing extra work upon the boiler to heat a certain number of square feet of radiation.

I will admit that there is a necessary volume to the body of water as it passes through the radiator sections which it would not be well to reduce. This volume, however, has not as yet been definitely established. To more clearly illustrate my meaning, I shall make a comparison: A bath or range boiler 16 inches in diameter and 48 inches in length will contain 9,651 cubic inches, or a water capacity of about 42 gallons. The surfaces of the boiler amount to about 19½ square feet, and if the boiler surface were not galvanized, and its location such that air could pass freely over its surface, it would heat a room 6 by 9 by 10 feet, or 540 cubic feet of space, having average wall and glass exposure, to a temperature of 70 de-

grees in zero weather, with the water at from 160 to 170 degrees. I offer, in contrast to the above, a radiator, the actual size of of its water section, independent of feet, being 32 inches high, 9 inches wide, and 1¼ inches thick, its internal capacity averaging a pint of water to the square foot of heating surface, and the actual surface of section backed by water being about 6 square feet. Using the volume of water in the range boiler and distributing it among the sections of the radiator it would furnish water for 336 square feet of heating surface, sufficient to heat a school room 36 by 28 by 12 feet with average glass and wall exposure, but with only one change of air per hour, to 70 degrees in zero weather, the temperature of the water being from 160 to 170 degrees. There are radiators which may, in a measure, be likened to the range boiler, containing the maximum amount of water in their internal surfaces to the minimum square feet of heating surface.

During the past year I examined a hot water plant which had been in use two winters, but failed to give the guaranteed results, viz., a temperature of 70 degrees in zero weather with the water at 170 degrees. The boiler construction was favorable to a quick circulation, and under ordinary circumstances equal to heat the amount of surface attached to it. I examined the piping valves, fittings,etc., to discover anything which would be detrimental to the water circulation, but found it correct. The radiators were then measured and found to contain the necessary amount of surface to heat the required space. Upon making a rouhg measurement of the internal surface of these radiators, it was discovered that they would average nearly a quart of water to the square foot of heating surface. Here, it was very evident that the boiler had double work to perform, or twice the amount of water to heat per square foot of heating surface over the radiator which would average a pint of water to a square foot of surface. I suggested the use of another radiator, but I have since understood that the plant was removed without this trial being made, which I feel assured would have corrected the trouble. This is a most important factor in the successful working of a hot water boiler, viz., the amount of water to be heated per square foot of heating surface in radiators. Another important matter connected with the construction of radiators which seems to be entirely overlooked by the trade, is the grade or class of iron used in their manufacture. I have a customer who, after installing a heating plant, was compelled to remove the radiators used and substitute others in their place. This party is an experienced heating engineer, and had

many heating plants in the same vicinity in which the heating surfaces were apportioned the same, the conditions of exposure being equal and the results satisfactory. The unsatisfactory plant had been erected in the early summer, and during the first cool days of autumn its deficiencies were not noticed, but when the cold days of winter appeared a marked absence of heat could be felt. The boiler was large enough for the work to be performed. The system of piping was examined for mistakes and trappings; none were found to exist. It apparently was a problem that could not be solved. The idea then occurred that the radiators might be responsible for the results. The internal openings were examined for imperfect construction, resulting from dropping of cores, etc., in the sections, but the circulation was found perfect. Finally he wrote the maker of the radiators, who at once claimed they were all right, and offered to take them back if he could definitely establish the fact that the radiators were responsible for the conditions existing. A radiator of another make was procured, which was of sufficient size to heat a selected room, connected up to the system, and found to thoroughly heat this particular room. The balance of the radiators were removed and others substituted in their place with the result of the entire building being well heated and entirely satisfactory. The radiators which were removed were of a class which had usually given good results. They were shipped back to the factory and in transit a section was broken, the fracture revealing the fact that the iron was exceedingly hard and brittle, its structure being very close grained and of a silver color, indicating the presence of sulphur in the iron, possibly caused by sulphur in the coke used in the cupola for melting the iron. The internal passages in the sections of the radiators were very rough and had an appearance of slag, supposably caused by the use of a large amount of scrap iron in the casting mixture. This shows the vast importance of using a good quality of iron, one which has the maximum of porosity with high tensile strength.

The competition in the sale of radiators is the cause, no doubt, in some cases, of the use of inferior grades of iron in their construction, and while the effect may not be so pronounced as above mentioned, it is undoubtedly an obstruction to the free passage of the heat units emanating from the element used for heating the radiators. My experience has been that a radiator, rectangular in shape, with flat surfaces, and containing about a pint of water to the square foot of heating surface, will give good satisfaction for water heating, other details of construction having proper attention, such as the

proper spacing of sections, permitting a free circulation of air over their surfaces, the connections between the sections being free from any projections which may impede free circulation of water. Ornamentation which increases the thickness of the iron in the sections is detrimental. Surfaces in direct radiation not backed by water should not be rated as effective surface, and where possible the preference for decorating radiators should be by metallic bronzes, their conductivity being much higher than enamels. A preference should also be given to radiators whose connections between sections are such as to permit the fitter to connect and disconnect them, allowing the assembling of radiation into required sizes from stock on hand, which is a decided advantage during the season when radiator factories are pushed to their utmost to fill orders. A failure to ship radiators promptly often causes vexatious and expensive delays. I hope our society in the near future may be in a position to obtain, by experiment and research, positive data on the details above mentioned appertaining to the construction of radiators for hot water heating.

DISCUSSION.

Mr. Fish:—I would like to ask the writer what he means when he states in this article: "It has been an idea with many engaged in the heating line that it is necessary to purchase a high-priced radiator in order to have them prove satisfactory."

Mr. Wilson:—What I mean by high-priced radiators is the standard types that have been accepted as such. With the ordinary rectangular shape of flat radiator I have obtained very good results, and they contain, I think, considerably more water per square foot of section.

Mr. James A. Harding:—The paper says, "It was very evident that the boiler had double work to perform, or twice the amount of water to heat per square foot of heating surface over the radiator which would average a pint of water to a square foot of surface." I would like to ask, if the same radiators are used (i. e., the same external surface radiators), of the same quality of iron and covered with the same kind of bronze, and one contains twice as much water as the other, how, as the loss of heat from that water is by transmission through the iron only, it can be proved that with one it will require twice as much boiler power to heat the building as with the other.

Mr. Wilson:—The assumption is that the volume of water to be heated will take a certain number of square feet of surface to heat it. I have reference to radiators with a small amount of external surface with large internal surface, giving a larger volume of water.

Mr. Harding:—Does it not evade the point to compare the amount of heating the radiator has to do with the amount of water it contains?

Wr. Wilson:—Yes, in one sense it does, and in another it does not. For instance, to give an illustration, take a 4-inch pipe and make it into an oval so that the body of water shall be thinner through; I claim you will do considerably more heating because there will be less water to the square foot.

Mr. Harding:—That is to say, less water will come in contact with a greater heating surface. But that does not answer the question as to the power of heating a building in the boiler or water itself.

Mr. Wilson:—I simply cite this instance for discussion.

Mr. Harding:—This is the question. The paper says, "it was very evident that the boiler had double work to perform." Now, as I understand it, the boiler has to set so many heat units in motion, and the transmission of those heat units through the iron into the room accomplishes the heating of the room; it doesn't make any difference whether it be through the medium of a thousand gallons of water or two quarts. If your iron is crystallized, or of bad form, you need more surface to accomplish the same purpose possibly, but eventually the relation between the boiler and the temperature of the room is just the same. My point is that the boiler does not have any more work to do with twice the amount of water.

Mr. W. M. Mackay:—I would like to say that in placing boilers or heaters for the heating of buildings by hot water, it is supposed that it is to take a certain length of time for the water to reach a certain temperature, in order that the heater shall be considered of sufficient capacity to heat the building. If you place a larger body of water on that heater it has to heat the water before it can impart the heat units to the building. It would not take a great deal more power after you got the water heated up, but it would take longer to raise the temperature of the radiators up to 180 degrees, and consequently with a larger body of water (while in the end it might accomplish the same thing), if the outside temperature were not changeable, it certainly would have some effect on the working capacity and efficiency of the boiler. With reference to Mr. Harding's point about the radiator only giving off the heat units, whether it has a pint or quart or gallon, or any other volume of water, there should be some stated quantity of water. There should be some minimum and maximum quantity of water in proportion to the surface of the radiator. There are radiators that have too little water, and con-

sequently the boiler has to lose power by friction while other radiators contain too much water and are too slow to heat up or cool off. In the early days of hot water heating, particularly in this country and Canada, they used the 1-inch pipe as the standard for the body of water and got better results than they are getting to-day with some makes of radiators with larger and smaller bodies of water; while, perhaps, Mr. Wilson's way of putting it is not just the way that some of us would understand it, I think his point is well taken, that it does take more power in the heater at times and under certain conditions.

Mr. Fish:—This paper of Mr. Wilson's I read with a great deal of interest, because it is on a line of thought that I have been advocating for years. I propose to speak from practice, and I will go back as far as 1885 in order to give you some of my experiments. I think I am quite safe in saying that at that time there was not a good hot water radiator made in America. That is a very broad statement. Bundy in 1885 was the first to bring out a hot water radiator. I am aware that the Bartlett & Hayward Company made hot water radiators before I was born. I am aware, also, that the Walworth Manufacturing Company, and concerns, half a century you might say in business, made crude forms of radiators for water heating purposes. But I am speaking now of the modern radiators, of the ornamental radiators, such as are being put into houses to-day. I think in 1885 I introduced into the New England states the first Bundy hot water radiator. In July, 1886, the H. B. Smith Company brought out the Union radiators. I have put in several types of water heating, using the Bundy radiator with very good results so far as water volume is concerned. But, unfortunately I found the surface, when a cold day came around, to be a little scant, and by rating it at three feet instead of three and a half, my surfaces panned out all right. In July, 1886, the H. B. Smith Company placed on the market the Union radiator, and one of my first questions was as to the amount of water the radiator held. Mr. Reed wrote me that the radiator held a quart to the square foot. I had previously, like my friend Mr. Mackay, practised hot water fitting in Canada. Our standard there, as Mr. Mackay said, was always based on the 1-inch pipe. There were no radiators made then as I recollect. We used to have old-fashioned box coils with screens and marble tops. But a manufacturer in selling a boiler rated to carry so many lineal feet of inch pipe, if Mr. Mackay was figuring on the Smith boiler, and I was figuring on the Jones boiler, the boiler being rated on inch pipe, our water volume became a certain fixed quantity so

far as radiation was concerned. I put in the Union radiators and some Bundy radiators on test, and I took one of our own make of boilers that was rated in Canada at that time at 1,500 lineal feet of inch pipe, equivalent to 500 square feet, and the Bundy radiator would heat quicker by experiment than the Union radiators, and the boiler temperature in the case of using the Bundy radiators, or with inch-pipe coils, a 1,500 foot boiler would carry a temperature from 170 to 200 degrees on the boiler with a larger body of water than the Union radiator or a radiator of that type. I could not get a temperature of over 140 or 150 degrees, and I could very easily see why hot water heating got a black eye, so to speak, on a cold day. We want not less than 180 to 200 degrees on a 10-degree-below-zero day, in an ordinary suburban house and sufficient boiler power to keep the water at those temperatures with fuel economy, burning a small amount of fuel or burning it economically. I have written several articles on this subject. By taking the boilers rated by this manufacturer and the other, it makes a great deal of difference what kind of radiation you are going to use with the boiler, if you are going to have a successfully heated house, and I have made it a practice when figuring on a job, if a man desired to use a heavy water radiator, to calculate the volume of water that I was going to have in my heating apparatus and proportion my boiler accordingly, so that the water in the apparatus should be heated to a standard of 200 degrees of temperature. With a steam heating apparatus, so many square feet of boiler power to so many feet of radiation in a room may work out very well. It is an accepted formula that a square foot of boiler surface exposed to the direct action of fire will boil eleven gallons of water in an hour. I call that three gallons instead of eleven, and proportion my surface on the water boiler and select my boilers accordingly, and I have not had any failures. When a fitter comes into my office to select a boiler and says, "will that boiler heat 700 feet?" I will say to him, "That depends. If you are going to use a 4-inch pipe, it will not; if you are going to use an inch pipe, it will. You can heat a 4-inch pipe with it, but you may get only 120 or 130 degrees temperature. But if you use an inch pipe, or radiators on about that same basis (I would not restrict myself to an inch pipe, inch and a quarter will do; but some are going up to a 4-inch pipe and that will over-tax the boiler), the better the apparatus will work, the higher the temperature you can get with it, the less the consumption of fuel; and if you want to reduce the temperature of the room quickly at any time, you can do it with a radiator holding a smaller amount of water,

and on that basis I have figured, and I have had fairly good success." I think this is where a very great error of judgment has been made by many of us, and by a good many the hot water boiler to-day has been damned and taken out. It has not been over-rated at all; it has been over-loaded, it has been soaked, and as water is our medium of heating, if you have a large body of water in there you have to provide grate surface and heating surface to get the temperature to where you want it on a cold day, and I believe that temperature is about 200 degrees. So far as my own influence has gone, I have time and again spoken to the radiator makers and said: "I hope the day is coming when we will get down to a standard." I sell a radiator that has 13 gallons to 100 feet of surface, and my neighbor sells one that has 35 gallons to 100 feet of surface. You can easily see that these radiators would give different results under certain conditions. What we should urge upon the manufacturers to do is to make a radiator of standard water capacity, based upon a 1-inch pipe surface with full areas of radiation. Then, design and construction would be the important considerations in the choice of a radiator.

Mr. Harding:—I concede the point made by Mr. Mackay that the smaller the amount of water contained in the entire circulation of the hot water plant the quicker you will note the heat of the boiler in the rooms. I also concede Mr. Fish's point, which is a very much more important one. The application of Mr. Mackay's point will be only once a year, assuming that the fire will be started in the fall and will not be let out until spring. But it makes a vast deal of difference to the comfort of the inhabitants of the house whether you can cool off the apparatus quickly. I see the importance of having the minimum amount of water, so that if the radiator contains one pint of water to each square foot of surface instead of one quart, you will have to wait only one-half as long after your apparatus has run up to 80 degrees before it cools to 70 degrees. The relation is in the coal that is burned and the amount of radiating surface through which the heat is transmitted to the air, and there are no other relations which regulate the capacity of the boiler after the water is once heated. We assume that it costs more in one case to heat the water to its maximum temperature, but once heated to that point, the power will be the same whether the quantity of water is twice as much or half as much.

Mr. Fish:—I am aware that you can heat a larger body of water. It is simply a question of grate area and heating surface and coal. But I am a believer in a standard, and we ought to

get the radiator men to make a radiator that will not only be standard in name, but standard in quality and quantity.

Mr. W. M. Mackay :—I would like to qualify my previous remarks. You have not got to heat the water only once a year ; but, as the average hot water apparatus is attended to in the average house you have got to raise the water in temperature perhaps two or three times a day. I have heard people state that you can raise an apparatus ten degrees an hour and all that sort of thing, but I have seen good apparatus with which it was impossible to do that. I do not know a single apparatus that is kept continuously at anything near the temperature that would give a uniform radiation from the radiators. The temperature of the water will vary from night until morning probably thirty to forty degrees. If it is going to take twice as long to rise thirty or forty degrees, that apparatus and that boiler will be condemned, through a mistake of the fitter or through a mistake of the manufacturer of the radiator, who perhaps knew nothing about the subject he was working on. The fitter buys the boiler; he puts it in a building. Through some mistake in selecting a radiator which did not have the surface, contained too much water, or something of that sort, that heater which, in this building might make a failure, in the next building, under what would seem to be exactly the same conditions, would be a success and would heat that building by eight or nine in the morning, where in this it would not do it by twelve. On the same ground I claim that it is a mistake to use a boiler with large steam space for hot water heating. There is where the trouble is, and there is where the steam boiler is not a good hot water boiler in many instances, because, on account of the amount of water in the steam space, it does take longer to heat up or cool down. We often have variations in our outside temperature of 20 to 30 degrees in a single day, from night till morning. I have tried a good hot water heating apparatus and found that I could raise the temperature of a building about four degrees an hour. That would take two and a half hours to raise the temperature of the building ten degrees. This would have to be done every day, and while doing it with a forced fire the heated gases would be passing up the flue at a high temperature. Some might be willing to waste fuel in order to obtain heat but there is where there would be a loss of heat, and the heat units that ought to be coming from the radiators would be going up the chimney.

Mr. Percival H. Seward:—I do not see that any one has demonstrated yet how it takes twice the boiler power to heat the larger amount of water. We all admit that it takes a certain amount of

heat units to heat a given sized room. To get a certain amount of heat units we have got to cool so many pounds of water. If we have got a radiator that contains so many gallons of water, to cool so many pounds so many degrees the water has to circulate at a certain velocity. If we have twice the boiler capacity it circulates at half the velocity to cool a certain amount of water. Now, when it gets down to the boiler, I do not see why it takes any more boiler power to heat a larger volume of water, if it is passing over the surface at a lower velocity than at a rapid velocity. I cannot see where the difference comes in. I think it is just exactly the same. We have got to heat a certain amount of water and it takes a certain amount of coal to heat that water whether it circulates at a high or low velocity. I do not think that that point has been argued out yet, why the boiler power has to be increased when we increase the volume of water.

Mr. Wilson:—I think the point of Mr. Harding as to the cooling of the water is well taken. But the point I wish to make is this—possibly I did not present it clearly. Take a small boiler that will heat one hundred gallons of water per hour; if we heat 200 gallons I claim that, taking the ordinary plant that I have spoken about and heating this extra volume of water, there certainly would be an extra consumption of fuel and a forcing of the boiler. I cannot really see how gentlemen can argue that a boiler which will heat only one hundred gallons of water is thoroughly efficient to heat two hundred gallons.

Mr. W. M. Mackay:—If that boiler were kept up to a uniform temperature it would not require any more boiler power. But it is a fact that the average apparatus is not run at a uniform temperature, either with or without a regulator, and as a result it has to be raised so many degrees every morning. It is not kept at a uniform temperature, and as a result this thing has got to be done every day that the apparatus is used. To maintain a uniform temperature with the average fire they have got to have more boiler power or less water. If the apparatus were always kept at a uniform temperature, the cooling and the amount of fuel consumed would be the same regardless of the amount of water in proportion to the surface in the system. But an apparatus is designed to run at 160 or 180 degrees and is run at that temperature and perhaps beyond that temperature certain hours of the day, and perhaps the next morning it is down to 120 or 130 degrees. Then it has to be forced. A larger boiler would not have to be forced and would possibly maintain that temperature with careless firing. On that account it would seem that a larger boiler was necessary to do the work with the

class of hands that attend to it. But if you burn your coal so that the water is always maintained at a certain temperature, and the whole apparatus is carried at a certain temperature, then you can get on with the same capacity of boiler with one, two, three, or four hundred gallons of water. But if you have to raise and lower that temperature two or three times a day, it would require more boiler power, and more boiler power is the only solution of the case. It would mean that, or the taking out of the entire apparatus.

Mr. Harding:—The commercial bearing of this thing is entirely apart from the question that I brought up. Water will absorb heat units more rapidly at a low than at a high temperature. It is also apparent that a circulating system containing the greatest amount of surface will not need to have that water at a high temperature to heat the room. Although a little apart from Mr. Wilson's paper, it seems to me that an important feature of hot water heating is to reduce the number of heat units which you have to control in order that you may control them quickly. It is with the smallest amount of heat units you can possibly have in a radiator with a rapid transmission of them to the room that you come nearest to a perfect system, hence, is not steam heating the more satisfactory method?

Mr. Fish:—Take a tank 15 inches in diameter and suppose it contains ten feet of heating surface. The tank holds 30 gallons of water. You make a similar tank and put an inner tank inside, leaving three-quarters of an inch water way between. The proportions of water will stand about 30 to 5. You experiment with a gas jet and you will see that where you get the larger body of water up to 150 degrees the smaller body will reach 200 degrees under the same conditions. When the smaller body of water is heated you can reduce the gas jet. With the larger body of water, when you reduce the light, it becomes water-logged, whereas the smaller body is doing its work. We are looking for temperature when heating buildings. We want a hot radiator on a cold day; we want a radiator up to 200 degrees anyway, or I will accept 180 degrees. It would be well for the hot water heating engineer to look sharply to the medium of heating, that is the water, and proportion his surfaces and select his boiler accordingly.

Mr. Barron:—There is one feature of this paper that has no bearing on what has been discussed, but it strikes me very forcibly, and that is the prejudice or superstition shown here with respect to certain systems, if the gentleman will allow me to use the words prejudice and superstition. I am very superstitious myself and

therefore I like to combat it. The author of the paper says: "Another important matter connected with the construction of radiators which seems to be entirely overlooked by the trade is the grade or class of iron used in their manufacture. I have a customer who, after installing a heating plant, was compelled to remove the radiators used and substitute others in their place. This party is an experienced heating engineer, and had many heating plants in the same vicinity in which the heating surfaces were apportioned the same, the conditions of exposure being equal and the results satisfactory. The unsatisfactory plant had been erected in the early summer, and during the first cool days of autumn its deficiencies were not noted, but when the cold days of winter appeared a marked absence of heat could be felt. The boiler was large enough for the work to be performed. The system of piping was examined for mistakes and trappings; none were found to exist. It apparently was a problem that could not be solved. The idea then occurred that the radiators might be responsible for the result. The internal openings were examined for imperfect construction, resulting from dropping of cores, etc., in the sections, but the circulation was found perfect. Finally he wrote the makers of the radiators, who at once claimed they were all right and offered to take them back if he could definitely establish the fact that the radiators were responsible for the conditions existing. A radiator of another make was secured, which was of sufficient size to heat a selected room, connected up to the system, and found to thoroughly heat this particular room. The balance of the radiators were removed and others substituted in their place with the result of the entire building being well heated and entirely satisfactory. The radiators which were removed were of a class which had usually given good results. They were shipped back to the factory and in transit a section was broken, the fracture revealing the fact that the iron was exceedingly hard and brittle, its structure being very close-grained and of a silver color, indicating the presence of sulphur in the iron, possibly caused by sulphur in the coke used in the cupola for melting the iron. The internal passages in the sections of the radiator were very rough and had an appearance of slag, supposedly caused by the use of a large amount of scrap in the casting mixture. This shows the vast importance of using a good quality of iron, one which has the maximum of porosity with high tensile strength."

Twelve or fourteen years ago I went up to Utica and in talking with Mr. Wood, of the Utica Steam Gauge Co., he tried to show me the great advisability of using the Walworth radiator in preference to the Bundy, because the wrought iron had some peculiar qual-

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ities he could not exactly explain, that transmitted the heat so much better than the cast iron. That is just the same old superstition that seems to work along through the center of New York state. I do not think it affects people east or south at all. I cannot see what the quality of the iron, provided the thing is normally thick, has to do with its radiating efficiency at all. It does not seem to me that that has any bearing whatever. That is one of those cases where a man finds something that makes an explanation for him, and the explanation is good enough. It is just about like nine-tenths of our science of heat. The explanation that the scientific gentleman gives is good enough for him at the present time, but fifty years hence some other gentleman will find out something that will stand it on end. From my point of view, the character of that radiator in that particular instance had nothing to do with the failure of that radiator to heat the building.

Turning to another part of Mr. Wilson's paper, he says: "I will admit that there is a necessary volume to the body of water as it passes through the radiator sections which it would not be well to reduce. This volume, however, has not as yet been definitely established." Now I think every man who ever designed a hot water boiler established that in his own mind. He wanted to have as little water to do the work as possible. He wanted to do that work perfectly with as little water as possible. And the same applies to the men who design radiators. They want to design radiators that will do that work with as little volume of water as possible. I think our best hot water jobs to-day are almost perfect in this respect; that is, the radiator does the work with as little water as possible, the boiler does with as little water, and the piping with as little water as possible. Of course I have no right to talk about hot water. I have never done much hot water work and I do not know much about it. But that is the way those two things strike me, and I think it my duty to hit superstition, or what I conceive to be superstition, wherever I find it.

Mr. Fish:—I would say, so far as I know, that there is no radiator manufacturer who is using scrap iron. In the first place it costs more money to melt scrap iron than what you can buy new for. It must have been a cross-roads foundry that is referred to. I agree with Mr. Wilson's paper regarding hot water radiator construction. When hot water heating was introduced into this country hot water radiation was a scarce commodity, and I had letters from many of the radiator manufacturers at the time asking my opinion as to how to make a hot water radiator. They took their steam patterns, just as he says, and converted them over without

any regard to any water volume. In Canada hot water heating is the standard and there 1-inch pipe is the standard.

Mr. Wilson :—I would like to qualify my statement, gentlemen, in regard to the matter of using scrap. Those who are familiar with foundry practice know that in even the very best of foundries there is a certain amount of scrap used, and it is considered good practice; that is, machine scrap, and it is used to make a good mixture. We also know that the scrap I have reference to is a poor quality. Persons would hardly care to use the same kind of scrap in sash weights as in radiators. It is well known that nine-tenths of the foundries hold it as a secret. A great many think they get higher conductivity and greater tensile strength by using different mixtures. Some use a considerable amount of silicon for a hard iron. Others use a soft iron. All these mixtures are peculiar to different establishments. I do not believe it would be as pronounced as I have mentioned it. I have simply taken it second hand. But I know other places, and I have positive proof of the conditions which present themselves, but whether they are from those causes or not I am unable to say. I simply presented this to promote discussion, of which I think it has been productive. I know I have been pretty well tanned, but a big fellow like me can stand that. I feel grateful to all who have criticised it, because it is a matter that has been of benefit to us all. I think every paper should be thoroughly discussed and criticised. I thank you all, gentlemen, very much.

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VII.

A PRISON HEATING AND VENTILATING PLANT.

BY H. B. PRATHER, BUFFALO, N. Y.

(Member of the Society.)

The subject of sanitary heating and ventilating of prisons and penitentiaries seems to be one that has not received the attention which its importance warrants. These institutions, which are often, if not usually, too small for the requirements, and often crowded with the lowest of human beings, offer an interesting problem for the heating and ventilating engineer. A casual visit to some of these buildings will effectively demonstrate the need of great improvement, and it is with a view to call up discussion and an instructive interchange of ideas and experiences that the writer brings before the society this description and study of a successful prison heating and ventilating plant, believing that it is unique in many ways, and has been in its operation and results a most practical demonstration of the efficiency of the arrangements and apparatus used.

The plant is located in the county prison of Ohio County, W. Va., at the city of Wheeling. The building, which is shown by Fig. 15, a fine sample of prison architecture, and a lasting monument to the ability of its architect, Mr. M. F. Giesey of Wheeling, W. Va., is situated on high ground and exposed to the cold winds which at times sweep over the Ohio Valley. Zero weather has occurred each winter since the plant was installed by Messrs. Trimble & Lutz of Wheeling, W. Va., about three years ago, and ample opportunity given for tests, which were made, as hereinafter referred to. The structure is of brick and stone, very substantially built, and above the average in outside appearance ; it includes cell and office building and jailer's residence.

Of the accompanying cuts the transverse section, Fig. 16, and Figs. 17, 18, 19, and 20 show the internal construction. The cell room or building, as it is variously denominated in this article, and as particularly shown by Figs. 16, 18, and 19, with heavy brick and

stone outside walls and brick and iron cell cage, with attendant galleries, etc., presents the most important features of the heating and ventilating plant. The entire building is heated and ventilated by a hot air plenum system, the fresh air being impelled into the

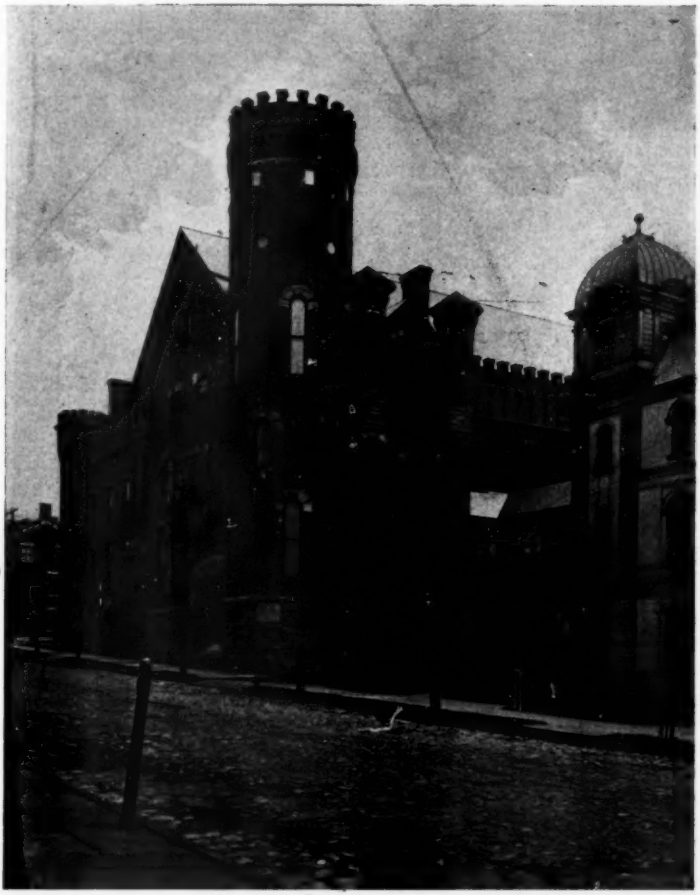


Fig. 15.—OHIO COUNTY JAIL, WHEELING, W. VA.

building after being properly heated by steam coils, and the foul air exhausted out by means of fans. In the basement, under one corner of the cell building, is located a Buffalo Forge Co. steel plate fan, and in front of the fan a Buffalo hot blast heater; this

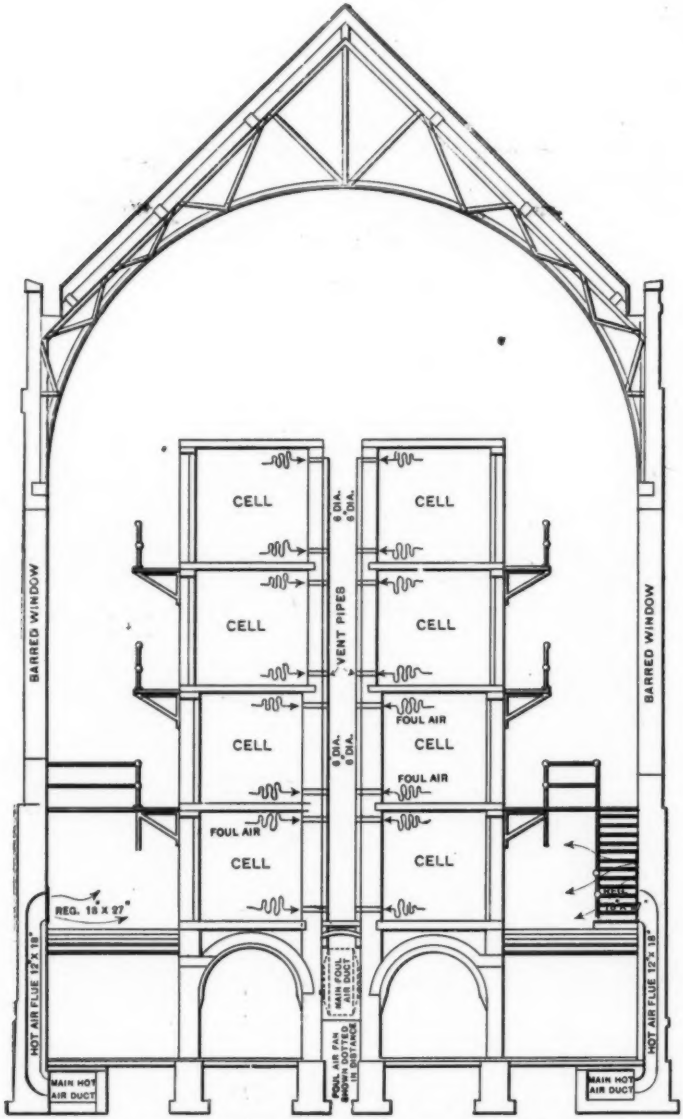
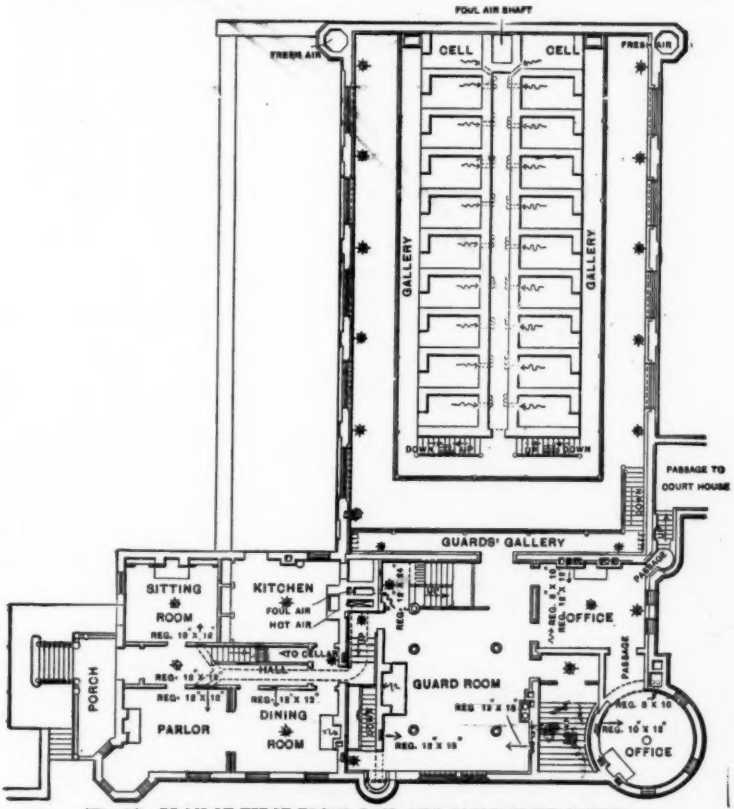


Fig. 16.—TRANSVERSE SECTION OF CELL BUILDING.

fan draws the fresh air in through the fresh air duct and blows it over and past the heating pipes or coils and thence through a sheet iron connection into the large main hot air duct which runs along the walls and under the cell building and has various branches to office and jailor's residence parts of the building. Up from this main duct lead the flues for the cell room and other portions of the building, supplying them with fresh warmed air in winter and unwarmed air in summer.

Warm air is introduced into the cell room through wall registers



[Fig. 17.—PLAN OF FIRST FLOOR JAIL AND JAILER'S RESIDENCE.

about 6 inches above the floor and one or two large floor registers, and into all other rooms by wall registers located about 8 feet above the floor. Vent faces for the eduction of foul air are placed

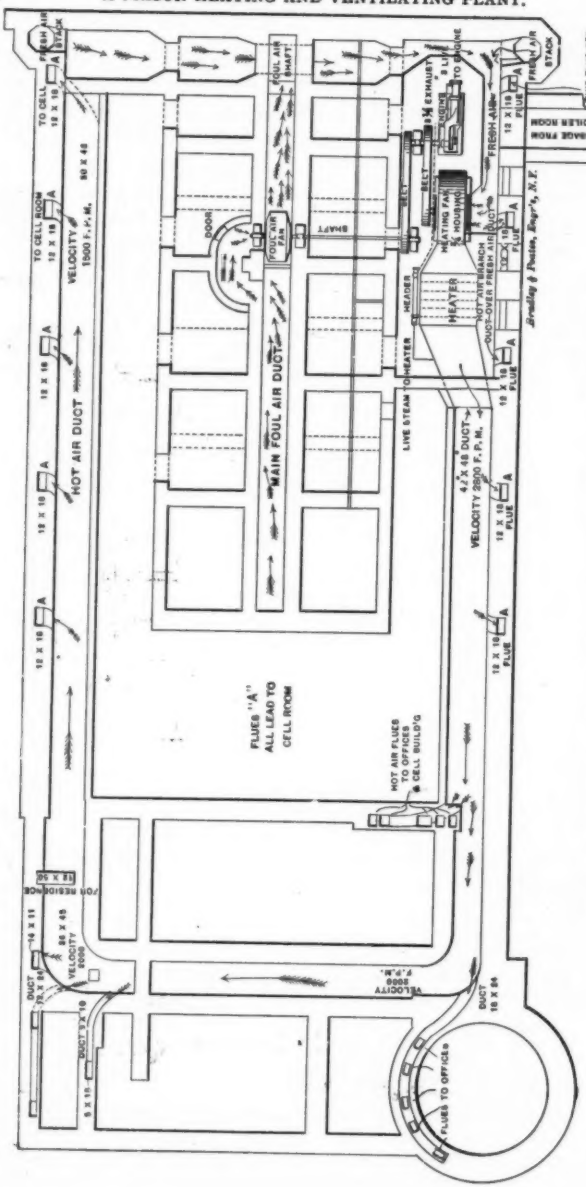
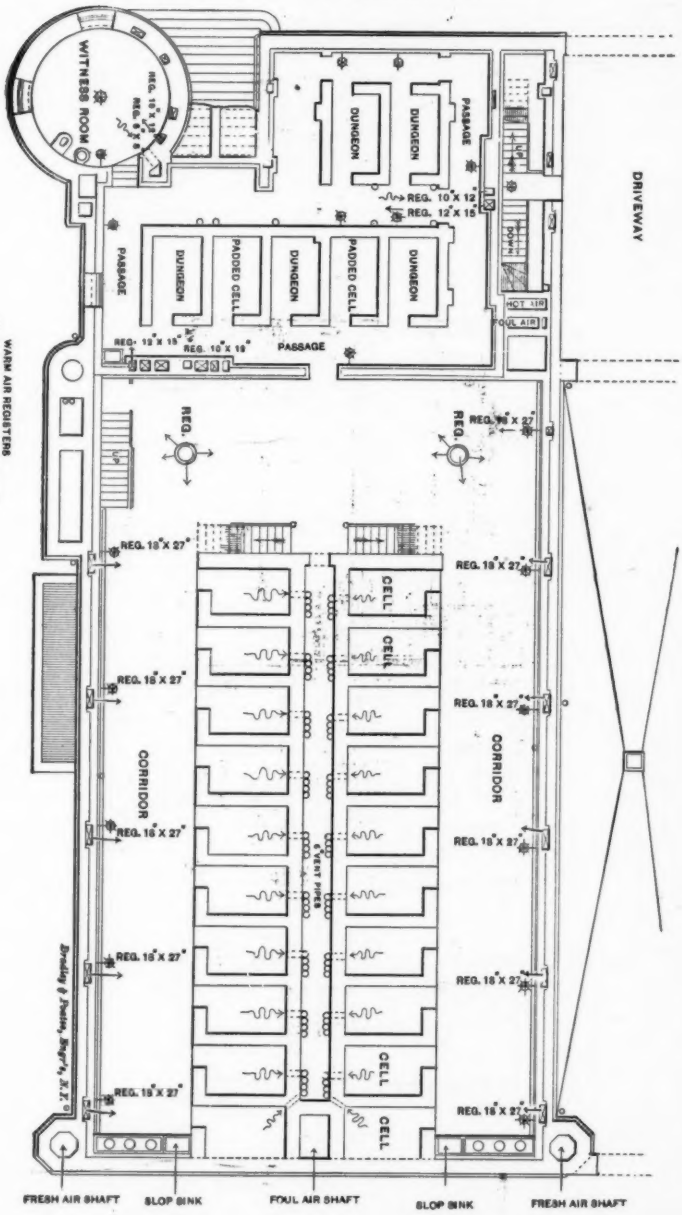


FIG. 18.—BASEMENT OF CELL BUILDING, PLAN OF HEATING APPARATUS.



WARM AIR REGISTERS INDICATED BY ARROW, THUS ⟶
VENTS INDICATED, THUS ⟿

Fig. 19.—PLAN OF GROUND FLOOR OF JAIL.

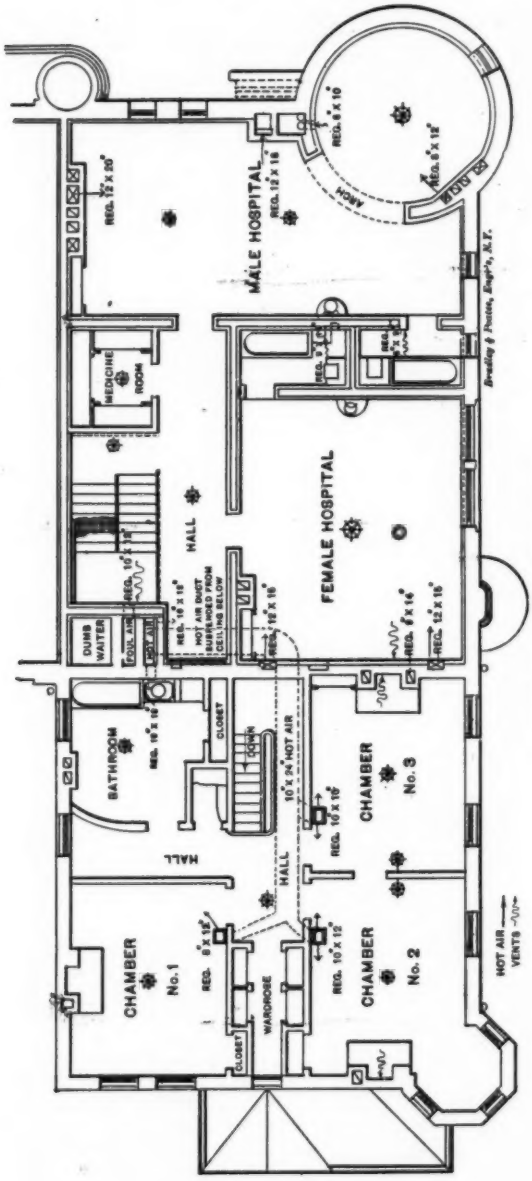


FIG. 90.—PLAN OF SECOND FLOOR.

in the walls at the floor line in all rooms, except cell room, and have flues leading to the main foul air duct in the cell building. The cells in the cell room are arranged in tiers (see Fig. 16), and have two 6-inch vent pipes, one from near the floor and one from near the ceiling for each cell ; these vent pipes lead down to the main foul air duct. The foul air passing through the main foul air duct to the foul air or vent fan is led around into the inlet of the fan and thence discharged up a shaft to the roof and outdoors.

The fresh air supply for the heating fan is led down a tower shaft from high up near the roof, thus avoiding the induction of dust and dirt from the street. The vent or foul air fan, located in the basement of the cell building, is a Buffalo blast wheel with a wooden periphery, the scroll and sides of the foul air duct serving as sides for the fan housing. In the same room as the heating fan and heater, which is called the apparatus room, is located a Buffalo horizontal side crank engine. This engine is belted to both heating and vent fans.

The boilers for the steam supply are located in an adjacent building, but connected by a passage with the apparatus room. Fig. 18 shows the arrangement of heating and vent fans, the heater, engine, and main hot and foul air ducts, with branches. So much for a general sketch of the methods of induction and eduction of the air and the general arrangement of the plant. We will now take up the details of the apparatus and ducts, and the results and data obtained by tests and usage.

Sizes of apparatus are as follows : Heating fan, No. 53 Buffalo, shell 110 inches, three-quarter steel plate housing, one-quarter of brick and underground, blast wheel 76 inches diameter, 33 inches wide, outlet 34 by 34 inches, area outlet 8.02 square feet ; heater containing 5000 feet capacity of 1-inch steel pipe ; vent fan or blast wheel 72 inches diameter by 30 inches wide ; engine 10 by 12 with 3-inch steam and 3½-inch exhaust, and throttling governor.

General data of building is as follows : Cubic contents, total, 341,000, side walls of cell building 40 per cent glass windows and no windows in end walls ; other rooms in building have medium glass exposure of 20 to 30 per cent. All windows excepting the residence are, of course, heavily barred. Ratio of heater to cubic contents of building 1 to 68.2. Sizes of main hot air duct at various points are given on Fig. 18 and others. Vents vary in area from ½ to ⅔ that of the hot air supply according to the usage of the room.

Tests on this plant on a cold windy winter day during its first

season showed as follows: Speed of engine 170 revolutions per minute; speed of heating fan 280 revolutions; average velocity of air at fan outlet 4,935 feet per minute; area of the main air duct at the heater 14.1 square feet; velocity of air at heater in main duct 2,800 feet per minute; volume of air delivered at same point 39,480 cubic feet per minute; temperature of air in fresh air duct before heating 3 degrees F.; temperature of air in main duct at heater after heating 143 degrees F., showing rise of temperature of 140 degrees; temperature of hot air at extreme end of main hot air duct under the cell room 100 degrees; ratio of heater to air heated 1 foot heater to 7.896 cubic feet air per minute; a velocity of air passing through heater pipes 3,200 feet per minute; average velocity of air through the registers in the cell building 500 feet per minute; average velocity up flues 900 feet per minute; average register velocity in extremes of residence building 400 feet per minute; average temperature of incoming hot air at registers 110 degrees in cell building, and from 100 to 106 degrees in extremes of office and residence; average temperatures maintained as follows: cell building 74 degrees, residence and office 68 and 70 degrees at extremes; steam pressure on heater, 2 pounds; exhaust on one-half of heater and 10 pounds live steam on the other half of heater; of vent fan 187 revolutions per minute, and air delivered by it, 21,000 cubic feet per minute; all tests of air velocities were made with air meters and a test of all hot air registers showed a delivery of sufficient volume into the rooms to effect a change of air in the cell room every 8 to 10 minutes and all other parts every 10 to 12 minutes; average air change for whole building 10 minutes; power used in driving fans was 23 indicated horse power, and considering both fans i. e., 39,480 cubic feet per minute delivered by heating fan and 21,000 cubic feet per minute by vent fan, or a total of 60,480 moved by both fans, we have 2,629 cubic feet per minute moved per indicated horse power, and at 4,935 or, call it, 5,000 feet per minute, about $\frac{1}{8}$ of an ounce pressure at the fan outlets.

From the above data, and figuring the average change of air in all parts at 10 minutes we note that the air delivered into the rooms is 34,000 cubic feet per minute, and the difference between the air delivered into the main hot air duct, i. e., 39,480 cubic feet per minute, and the amount delivered in the rooms is 5,380 cubic feet per minute, or a loss of 13.7 per cent of the amount delivered by the fan. This loss is undoubtedly principally due to leakage, friction, and contraction of volume due to cooling.

Another interesting calculation from this data is to estimate the number of heat units delivered into the air heated per minute per foot of heater, as follows, using the
Formula (from Nystrom)

$$H = \frac{V}{50} (T° - t°)$$

wherein V = volume of air to be heated per minute in cubic feet.
T° = temperature of the heated air.
t° = temperature of air before heating.
H = heat units required to raise temperature of V volumes of air from t° to T°, and using data from this test we have H=(39,480÷50) ×(143°—3°)=110,544 heat units delivered into the air heated from 3 degrees to 140 degrees by this heater, and the average number of heat units given off or delivered by each foot of heater is 110,544÷5,000=22,272. Of course this is not an exact calculation of the total heat units developed by this heater, but it gives an interesting illustration of the number of heat units delivered per foot of pipe with this style of heater, with a ratio of 1 foot of heater to 7.896 cubic feet of air heated per minute, and with a velocity of air passing the pipe of 3,200 feet per minute and with steam pressures, temperatures, and other conditions as given above. It was impossible to make a "condensation test" of the heater, which would have more accurately demonstrated its heat efficiency and developing power.

A more rapid change of air in the cell room can be easily effected when desirable by speeding up the vent fan (proper provision for extra admission of fresh air to the cell room and for the prevention of undue exhaustion and draughts in other parts of the building being made), and is done each day early in the morning when the slops are being emptied, beds being made in cells, and a general cleaning up takes place, the change of air often being as rapid as every 5 minutes.

This point of variable, rapid, and positive ventilation of the cell room is one of the most important features of the heating and ventilating plant. The stench in the foul air duct at the discharge of the foul air fan when this cleaning up and the rapid ventilating above referred to is taking place is frightful and unbearable, while the air in the cell room itself is as pure to the sense of smell as at any other time, the foul odors apparently being instantly exhausted out as fast as they are produced by the stirring up, emptying of slops, etc.; and the odor of this discharged foul air is at all times a practical demonstration of the need of perfect ventilation and the value of the methods employed.

The consideration of the interesting item of boiler power used was impossible of as exact determination as was desired owing to the fact that the boilers were partly used for supplying a direct heating plant in the adjacent court house building, but from all data to be had the boiler power used for this plant was 60 horse-power at time of the test. It was impossible to make a fuel consumption test, greatly to the regret of the writer. Tests were also made of this plant in a zero spell of weather during the same winter in which this test was made, and the temperatures, air changes, and data obtained were practically the same as in this more complete test, which was made, as stated in first part of this article, with temperature of 3 degrees above zero, but on a windy, dry day.

As a conclusion of this paper it is pertinent to state that this plant has been in use and operation constantly for nearly three years, has given entire satisfaction to all concerned, and by its daily use and several tests has fully exemplified the utility and efficiency of the system for this kind of a building. Of course many possible and valuable improvements were suggested here and there in the tests and using of the plant, and some have been and will be taken advantage of and utilized in the design of future plants for similar conditions and service.

DISCUSSION.

Mr. Jellett :—When I received this paper in the middle of last week I looked back through some of my old note-books to see what I had bearing on prison plants. I find that in 1891, in August, I inspected the Western Penitentiary at Allegheny, Pa. That is a penitentiary that is built to accommodate some 1,000 or 1,200 prisoners and is designed in such a way that it can be extended in a number of different directions. It is built on the usual modern form of a rotunda, a number of cell houses running from that as the spokes from the hub of a wheel. Each cell house accommodates some 540 prisoners. At the present time they have two cell houses for male prisoners with about 900 prisoners. Prisoners from the western part of the state are sent to Allegheny; those from the eastern part to the Eastern penitentiary at Philadelphia. This plant was first constructed in 1883, and it has been the model for most of the other plants. In fact, I rather believe that the Wheeling plant was modelled after examining the plant at Allegheny. I know the Huntington Reformatory was. The matter of heating and ventilating a prison is an entirely different problem from any other class of building. You must be particular about the use of registers or dampers, or anything of that

kind which a man could use as a weapon by breaking it, or which he could use as a means of suicide. These two things must be considered in designing a prison plant, and the care that is used in such a plant is a great deal more than most men who have not had to do with it imagine. It is a difficult thing to get a given amount of area and at the same time to have it in such a way that it is inaccessible and that it cannot be choked up. The prison at Allegheny has a large cell house, and from my notes I can give you some idea of it. It is 60 feet wide in the clear and some 350 feet long. The building is built as a large shell. Another building is built inside of that known as the cell or tier house. That is independent of the outside walls and of the roof of the outer building. There is 15 feet of space all around between the cell house and the outer building, so that the prisoners are in a building within a building. There are galleries leading to the cells, so that a man with a rifle in the rotunda can see a prisoner at any place, as the line of galleries is directly in the line of the axis of the rotunda. The watchman has an indicated position. Simply making his circuit on that line he comes in direct line with every line of cells. It is the form that is being generally adopted for prison use. The new county prison in Philadelphia is modeled on the same plan, but is only using a one-story cell house on account of having plenty of ground room; they are also using a different method of heat. The Allegheny plant is heated entirely by the hot blast system. There are eight heating fans and four exhaust fans 12 feet high by 4 feet 6 inches wide. The force fans are run at 200 revolutions per minute, and they change the air in the cell house every 15 minutes. The building contains nearly 2,000,000 cubic feet of space. The exhaust fans are run at 250 turns per minute; they exhaust about 70 per cent of the amount of air forced in by the blowing fans. The loss of the rest is due to leakage of the large cell house windows. As the cells themselves get their light through the walls of the outer building, with which they have no connection, the windows are required to be extra large. Each of these fans is run by a 10-inch special engine. I examined the first part of the plant erected in 1883. The engines had not been renewed or any repairs put on them in that time. The heating coils are in front of the blowers in every case, and the air is forced through ducts in the basement under these cell houses and comes in at a point about four feet above the floor. The cells themselves are warmed by the air from the cell house. Each cell in the new building is some 7 by 9 feet. In the old buildings they were 5 by 9 feet. In the cell the prisoner has a bed, wash-

stand, and water closet, and there is a ventilating flue, but the fixtures and pipes controlling these closets and washstands are entirely independent of his use. There is simply a very heavy bowl built in and there is a regular flow of water through there that he cannot handle or control. In the same way the closets are flushed automatically from an outside source. The ventilating flues lead through the back wall. There is simply an opening in the wall with bars on the outer side of the wall. There is a 4-foot space that leads from the basement all the way to the top of the cell house. In that space all these various ventilating openings in the wall are connected by pipes and carried to the basement. The cells are five high and two rows in depth ; that is ten cells, 54 cells in length, making a total of 540 cells, requiring 108 combination flues of five each. In addition to these the soil pipes from the water closets and washstands have an open vent, a sort of a Y built into the pipe, and that is also conected with the exhaust fan. The exhaust fan in the basement pulls directly on this cell house, and the air is carried to a different part of the grounds altogether through a duct and blown from the discharge flue at a point where it will not contaminate the in-coming supply. This system has been used, as I said, since 1883. When the new wings were built in 1888 and 1889 the system was still further developed, and the warden in charge tells me it is the most satisfactory thing in prison heating that has ever been designed, and he is considered by the Board of Prison Reform of the United States as one of the most expert managers of penal institutions that we have in the country. He studied it from a sanitary point of view, because he is using his prisoners in the shops. He gets a certain amount of work out of them and he has to some extent supported the institution by the labor of his men, and, as he says, a healthy, able-bodied prisoner is a much easier man to manage than a man in bad health, because the latter is always kicking up a row.

VIII.

THE LITERATURE OF HEATING AND VENTILATING.

BY HUGH J. BARRON, NEW YORK.

(Member of the Society.)

The literature of modern heating and ventilating commences with Robertson Buchanan in 1810, but it would be a very rash surmise to assume that that particular time marked the beginning of these arts. True research will, I believe, show that they have been evolved slowly and gradually, like everything else in the world, and that no one man or no one nation marked their obscure beginnings. The specialists in heating who arranged the Roman baths of two thousand years ago were no mean engineers, and the art as then practiced, with the complicated system of heating the walls and floors, and the intricate manner of warming and supplying the water, with the peculiar means of circulating the air from room to room, prove that then the art was not new, but had been long established.

The art of building baths has gone on in the world continually since that time, so that the art of heating, in one of its minor forms that we are acquainted with, has a very ancient connection, and I am satisfied that if we had access to the information contained in the Latin, and the French and Italian offshoots of that language, we would find that the protoplasm of the literature of this subject goes very far back.

I think it advisable at this place to insert a list of all the literature on this subject that I have been able to secure the use of. I have divided this list into three parts, the first consisting of books, the second part of essays, and the third of catalogues. I have excluded everything that does not pertain to the arts of heating and ventilating as a special field of effort, and I have been particular to avoid the scientific aspects of the subject of heat and of steam engineering. I have, as far as possible, given the dates when the works were published. There will, of course, be some errors, due to different editions of the same work and other causes. These lists, I am satisfied, do not contain half the works that have been published ; many are lost ; more are inaccessible.

In the development of the arts no work of man is to be despised ; even the most rubbishy is interesting as a milestone on the march of human progress. Philosophers now generally realize that the histories of nations are in their arts and their literatures. The true history of this special art is in its literature, and when that is carefully examined it will be found that its development has been due to the thousands of unknown workers that have been engaged in it, and that any one man's share in the advancemet has been very small indeed.

BOOKS.

A Treatise on the Economy of Fuel and Management of Heat. Robertson Buchanan, C. E. Glasgow, 1815.

Conducting of Air by Forced Ventilation. Marquis de Chabannes. London, 1818.

The Principles of Warming and Ventilating Public Buildings, Dwelling Houses, etc. Thos. Tredgold, C. E. London, 1824.

Warming, Ventilation, and Sound. W. S. Inman, London, 1836.

The Principles of Warming and Ventilating by Thos. Tredgold, with an appendix. T. Bramah, C. E. London, 1836.

Heating by the Perkins' System. C. J. Richardson. London, 1840.

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A Practical Treatise on Warming by Hot Water. Chas. Hood, F. R. S. London, 1844.

History and Art of Warming and Ventilating. Walter Bernan, C. E. London, 1845.

Warming and Ventilation. Chas. Tomlinson. London, 1844.

Walker's Hints on Ventilation. London, 1845.

Practical Treatise on Ventilation. Morrill Wyman. Boston, 1846.

Traite de La Chaleur, E. Peclet. Paris, 1848-59.

Practical Method of Ventilating Buildings, with an appendix on Heating by Steam and Water. Dr. Luther V. Bell. Boston, 1848.

Warming and Ventilation. Chas. Tomlinson. London, 1850.

Practical Ventilation. Robert Scott Burns. Edinburgh, 1850.

Ventilation and Warming. Henry Ruttan. New York, 1862.

A Treatise on Ventilation. Robert Ritchie. London, 1862.

American Edition of Dr. Reid's Ventilation as Applied to American Houses, edited by Dr. Harris. New York, 1864.

A Treatise on Ventilation. Lewis W. Leeds. Philadelpha, 1868, New York, 1871.

Observations on the Construction of Healthy Dwellings. Capt. Douglas Galton. Oxford, 1875.

Practical Ventilating and Warming. Jos. Constantine. London, 1875.

Warming and Ventilation. Chas. Tomlinson. London, 1876, Sixth Edition.

Mechanics of Ventilating. Geo. W. Rafter, C. E. New York, 1878.

Ventilation. H. A. Gouge. New York, 1881.

Ventilation. R. S. Burns. Edinburgh, 1882.

American Practice in Warming Buildings by Steam. Robert Briggs, with additions edited by A. R. Wolf. New York, 1882.

Steam Heating for Buildings. W. J. Baldwin. New York, 1883. Thirteenth edition published in 1893.

The Principles of Ventilation and Heating. John S. Billings, M.D. New York, 1884.

Heating by Hot Water. Walter Jones. London, 1884.

A Manual of Heating and Ventilation. New York, 1886. F. Schuman.

Ventilation. W. Butler. Edited by Greenleaf. New York, 1888.

Steam Heating Problems from the Sanitary Engineer. New York, 1888.

Metal Worker Essays on House Heating. New York, 1890.

Heat—Its Application to the Warming and Ventiiation of Buildings. John H. Mills. Boston, 1890.

Ventilation and Heating. T. Edwards. London, 1890.

Ventilation.—A Text Book to the Art of Ventilating Buildings. Wm. Paton Buchan. London, 1891.

The Ventilating and Warming of School Buildings. Gilbert B. Morrison. New York, 1892.

Hot Water Heating. Wm. J. Baldwin. New York, 1893.

Ventilation and Heating. John S. Billings, M.D. New York, 1893.

Warming by Hot Water, by Chas. Hood, C. E. Edited by F. Dye. London, 1894.

ESSAYS.

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Suggestions in Regard to Steam. Colonel William Cooke. Philosophical Magazine. London, 1745.

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Chimneys and Fire Places. Count Rumford. 1796. London.

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Hot Water Heating. John Eldridge. London, 1860.

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Paper by Gen. Morin of Paris, in the Proceedings of the Institute of Mechanical Engineers. London, 1863 and 1867.

Proceedings of the Institution of Civil Engineers. Robert Briggs on Fan Blowers. London, 1869-1870.

The Plumber and Sanitary Houses. S. S. Hillyer. London, 1870.

Salltzer's Treatise on Acoustics and Ventilation. Alexander Salltzer. New York, 1872.

Reports of Petterkoff, Angus, Smith, and Parkes. Investigations of London Houses. London, 1875.

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"The Engineering Record and Sanitary Engineer." New York, 1879-1894.

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Steam Heating. A paper read before the Engineer's Club of St. Louis, by Chas. A. Smith. Journal of Engineering Societies, Sept. 1882.

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On Warming and Ventilating. Arthur Morin. Smithsonian Institute. Translated by C. R. Young. Washington, 1884.

Parke's Manual of Hygiene. London, 1885.

Transactions of the Philosophical Society. Carnelly, Holden, and Anderson Reports. London, 1887.

Articles on "Heating," "Ventilation," "Baths," "Heat," Encyclopedia Britannica. London, Ninth Edition. 1887.

"The Master Steam Fitter and Heating Engineer," Chicago, Ill., 1888.

Ventilation of Public Buildings, Journal of the Franklin Institute. Thos. Elkington. Philadelphia, 1889.

Reports of Massachusetts District Police. Chief Wade. Boston, 1889.

Ventilation. A. R. Wolf. New York, 1890.

The Heating of the State House, Augusta, Me. Prof. Woodbridge, Boston, 1890.

Relative Economy of Chimneys and Fans. Prof. Trowbridge. New York, 1890.

Hot Water Heating—Low Pressure. F. Dye, London, 1890.

The Heating and Ventilation of the Massachusetts Institute of Technology. Prof. Woodbridge. Boston, 1890.

"The Metal Worker." New York, 1890 to 1894.

Health and Comfort in House Building. By Drs. Drysdale and Hayward. New York, 1890.

"Heating and Ventilation." New York, 1893-1894.

Ventilation of School Buildings in Massachusetts by Joseph A. Moore. International Convention of Factory Inspectors. Chicago and Boston, 1893.

Engineers' Index. J. B. Johnson. St. Louis, 1893.

Proceedings of the Master Steam and Hot Water Fitters' Association of the United States. Conventions of 1892, 1893, and 1894.

"Domestic Engineering." Chicago, Ill., 1894.

CATALOGUES.

A. M. Perkins & Son. London, 1845.

Walworth, Nason & Guilds. New York, 1850.

Morris Tasker & Co. Philadelphia, 1855.

Nason Mfg. Co. New York, 1860.

Hitchings & Co. New York, 1860.

Walworth Mfg. Co. Boston, 1865.

T. W. Weathered. New York, 1865.

Pancoast & Maule. Philadelphia, 1870.

H. Belfield & Co. Philadelphia, 1870.

John A. Scollay. Brooklyn, N. Y., 1870.

B. F. Sturtevant. Boston, 1873.

Walker, Pratt & Co. Boston, 1875.

New Haven Steam Heating Co. New Haven, Conn., 1878.

Crane Co. Chicago, 1878 to 1894.

XUM

Boynton Furnace Co. New York, 1880.
Holley Steam Heating Co. Lockport, N. Y., 1880.
Eureka Steam Heating Co. Rochester, N. Y., 1880.
W. B. Dunning. Geneva, N. Y., 1880.
Utica Steam Gauge Co. Utica, N. Y., 1882.
Hay & Prentice. Chicago, 1883.
Haxtun Steam Heater Co. Kewanee, Ill., 1884
Richardson & Boynton. New York, 1888.
Williames' System. Philadelphia, 1888.
Kelley & Jones Co. New York, 1888.
B. F. Sturtevant. Boston, 1888.
Pierce, Butler & Pierce. Syracuse, N. Y., 1888.
Gurney Hot Water Heater Co. Boston, 1887.
Osborne Steam Engineering Co. Chicago, 1890.
Babcock & Wilcox Co. New York, 1892.
Barnard Steam Engineering Co. New York, 1892.
Abraham Cox Stove Co. Philadelphia, 1892.
New England Engineering Co. Boston, 1893.
National Electric Heating Co. Chicago, 1893.

Robertson Buchanan notes that a certain M. Bonnemain exhibited at Paris, in 1777, an incubator heated by a coil containing water under pressure, thus anticipating Perkins' invention of high pressure hot water heating by 40 years, and the Baker car heater by 80 years. (See page 163 Tomlinson's "Warming and Ventilation.") Bonnemain's system was introduced into England in 1816 by the Marquis de Chabannes, who was long regarded as the inventor. In 1822 Messrs. Atkinson, Barrow, and Turner, and Mr. Baker introduced modifications of the apparatus, working at low temperature, and open to the atmosphere, in contrast to Perkins' high temperature. (See Dr. Reid, page 252). Perkins' distinctive features were in working at very high temperatures and using a water tube or coil boiler and a closed system.) He also refers to a certain M. Gauger's treatise on fire places, stoves, and chimneys, published during the 17th Century, and the translation of this work by Dr. Desaguliers in 1715 (the inventor of the fan blower—died 1749), and the treatise of our own Dr. Benjamin Franklin on chimneys, published in 1785, and to the Essay of Count Rumford on the same subject, published in 1796; but before proceeding to examine Robertson Buchanan's treatise I wish to note that his works are really the basis of Tredgold's work on both heating and ventilating, published seven or eight years later, and that both works are the basis for all the early inventions and improvements in heating and ventilating, and that they were the text books, reference books, and

guides of every worker in these arts from the period of their publication up to 1860, and I fully agree with that member, Mr. W. W. Phipson, of the Institute of Civil Engineers, who said that a thorough study of Tredgold is the best preparation for the study of heating and ventilating of to-day ; this statement was made in 1883. For those who doubt that the inventors and improvers of heating and ventilating apparatus in the early days of this century did use these works, I would ask them to consider who bought the three editions of Tredgold that were published ? There is only one answer—the engineers of this country and of England—the predecessors of the men who buy Baldwin and Billings to-day.

The full title of Robertson Buchanan's work is as follows : "A Treatise on the Economy of Fuel and Management of Heat, Especially as it relates to Heating and Drying by Means of Steam, in four parts ; first, on the effects of heat, the means of measuring it, the comparative quantity of heat produced by different kinds of fuel ; second, on heating mills, dwelling houses, baths and public buildings ; third, on drying and heating by steam ; fourth, miscellaneous observations, with many useful tables, illustrated by plates, with an appendix containing observations on chimney fire places, particularly those used in Ireland, on stoves, on gas lights, on lime kilns, on furnaces used for rapid distillation in the distilleries of Scotland, on improved boilers for evaporating liquids, by Roberston Buchanan, Civil Engineer, Glasgow, printed for the author and sold by Brash & Reid. Orme & Brown, London, 1815. Hedderwick, Printer."

Buchanan commences by referring to his Essay on Steam Heating for Buildings, published in 1807, and in the Philosophical Magazine, and in Nicholson's Magazine, and other publications in 1808. He goes on to say that Col. William Cooke suggested, in the Philosophical Magazine in 1745, the idea of warming rooms by steam. At that time Count Rumford stated that it had been so used in England and on the Continent, but nothing of importance was done until steam was applied to heating cotton mills, a patent for which was granted to John Hoyle, July 7, 1791, and another to Joseph Green, December 9, 1793. Shortly before this time the firm of Boulton & Watt commenced to experiment in steam heating. The radiator they used was made of tinned iron, $3\frac{1}{2}$ feet by $2\frac{1}{2}$ feet, held apart, at the distance of an inch, by means of studs, anticipating the old Gold sheet iron heater. It was connected up on the gravity return system, and fitted with an air valve. In 1789 Boulton & Watt overhauled a defective indirect steam apparatus in the Marquis of Landsdowne's library, erected by Mr. Joseph Green. It heated the

library by means of air heated by steam (indirect radiation). Before 1800 steam heating was adopted in the calico works and mills of England, Ireland, and Scotland, Boulton & Watt doing a great deal of this class of work, trying lead, copper, and tin pipe, and finally using cast iron pipe 3 and 4 inches in diameter.

In Houldworth's Mill one square foot of surface is allowed to each 175 cubic feet of space, and in a Chapel at Port Glasgow, one foot of surface to 400 cubic feet of space. The safety valves on the boilers are loaded to 2½ pounds working pressure, the pressure used by Boulton & Watt for their engines. Buchanan states that several mills heated with tin pipes have had the pipes painted black, making a great improvement in the effectiveness of the radiating surface. Vacuum valves are used to prevent the tin pipes from collapsing; extended surface by flanging the pipes is also tried; a combined expansion steam trap and automatic air valve is described; bolted flanges are used on the cast iron pipe, with red lead and iron joints. Tredgold describes, some years later, the use of ground joints between the flanges, and also faced joints with tin gaskets, lead having been tried and found defective. The drawings shown of the pipes and aparatus generally are splendid pieces of work. He describes hollow ornamented iron vases, filled with steam and used as direct radiators, and also describes trangular heating pipes to take the place of a cornice at the ceiling of rooms, for heating them. For dwellings he allows one square foot of surface to 100 cubic feet of space. The pipes are kept high so as to get water back to the boiler. He describes how Count Rumford heated the center room of the Royal Institution with copper pipes, having copper cylindrical expansion drums, practically the present expansion joint used by the New York Steam Co., or very much like it, also gravity return. The drawings of the boilers show an automatic water feeder, and also an automatic damper regulator. He goes on to describe buildings of every character that have been heated by steam, including dwellings, churches, counting rooms, libraries, baths, and printing offices.

In mills the expansion of the pipes is made to regulate the expulsion of the air and all unnecessary escape of steam. The end of each 4-inch pipe running the length of the factory is fitted with a puppet valve that closes by the expansion of the pipe, which is hung on rollers. In this apparatus the hot water of condensation is used about the mill or allowed to run to waste. He describes varous forms of hot air furnaces, stoves, and improved fire places. The work is splendidly arranged and written, being, in that respect, much superior to Tredgold's work, published in 1820-1824. This

work is styled,—"The Principles of Warming and Ventilating Public Buildings, Dwelling Houses, etc." by Thos. Tredgold, Civil Engineer.

Tredgold takes strong ground in favor of steam as opposed to hot water, and gives rules for ventilating. He shows how to ventilate water closets with a small worm steam coil connected with a small boiler, with gravity return. He shows a vertical float steam form of indirect radiator with metal casing. The third edition of this work, edited by T. Bramah, Civil Engineer, was published in London, 1836, with an appendix containing observations on heating by means of warm water, with descriptions of various apparatus. This work shows complete plans of low temperature hot water indirect heating and ventilating apparatus in the new Westminister trap of good design. He describes the use of wrought iron pipe and pipe couplings with screwed threads. He shows a perfect hospital, erected by J. Bramah & Sons, in 1829—a very superior looking piece of work. There are also plans of hot-house work shown with 4-inch cast iron pipe, just the same as is being put in everywhere to-day. (American, Canadian, and English greenhouse work, varies very little to-day from the work done by Bramah & Son. "Using 2-inch wrought iron or steel pipe for hot water, and the use of low pressure steam with small pipe in some places are the only changes." I think it probable that low pressure steam will supersede hot water for this work in time.) I should have stated that the indirect radiators shown in the Westminister hospital are box-coil type, cast iron, of the same pattern that are put in for similar hot water work in this country at the present time. Bramah states that Tredgold, if he were alive in 1836, would have preferred hot water, as the apparatus was then much perfected. He also regrets that Tredgold's efforts in the cause of ventilation have not been fully appreciated, and that ventilaton receives so little attention.

It is doubtful if it is generally realized how much the manufacture of wrought iron pipe has influenced American heating and ventilating. To it is largely due the ascendency of steam over hot water. For a long time the two lines of industry were so closely united here that they were considered inseparable, and the dealer or maker of pipe was generally engaged in steam heating ; yet concerns putting in hot water apparatus of cast iron construction, and exactly on the lines pursued in England by Bramah & Son, have been in business here for the last fifty years, and while they have from the beginning made efforts for heating all classes of buildings, the same as is done in England, and while from the beginning they have done isolated

jobs here and there, their influence in the general heating of buildings has been hardly felt, while they have entirely monopolized green-house heating and ventilating, so much so that they have become recognized as specialists in that particular line, and those engaged in the heating of buildings rarely interfere with them. Attempts are made from time to time to change what seems to be a natural law of specialization or natural selection, but the efforts have no permanent effect, and the two lines remain separate and distinct. (Steam fitting becoming a recognized branch of the pipe dealer's business in the early days, and the fact that it was neater and cheaper than hot water, had probably more to do with giving the ascendancy to low pressure steam than the climatic conditions.) A new hot water element, largely of Canadian growth or influenced by Canadian practice, entered the heating field some ten years ago, and has established hot water for heating buildings on a firm foothold, but this element has no, or very slight, connection with the old original hot water element that came from England. American steam heating developed from the Perkins' small wrought iron tube system as opposed to the large cast iron low temperature system ; it abandoned hot water and went back to the steam systems of Tredgold's and Buchanan's time, using small wrought iron pipe, whereas the low temperature hot water systems superseded the early steam systems in England.

This curious development of the arts of heating in the two countries has had many explanations, and I do not know that I have thrown any new light on the subject.

The steam heating that is done in England to-day is the natural outgrowth of the work of the contemporaries of Buchanan and Tredgold, and has proceeded uninteruptedly since their time, and has been little influenced by American practice. This is particularly true of mill and factory work.

I will neglect to say much about the development of furnaces and furnace heating and ventilating. Considered from the point of view of advanced engineering, their history and development is not worthy of much consideration. In all the arts, and, in fact, in all nature, progress is from the simple to the complex, and the hot air stove or cockle is only suitable to a simple and comparatively barbarous civilization. The men who have developed the forms of it for schools and dwellings have been influenced by a wrong conception of mechanical and industrial philosophy, based on the mistaken idea that simplicity and cheapness are more desirable than complexity and expensiveness. It is true that it has had its field of usefulness—every day, however, getting narrower.

The ascendency of the furnace is a sure mark of a shoddy civilization, of a low degree of culture, and of a pretentious and mean environment wherever it prevails.

Buchanan, Tredgold, and, in fact, all the early engineers, fought shy of it, and I doubt very much if one real engineer was ever engaged at any time in furnace work or in the advocacy of the use of furnace heating and ventilating, although men of great ability, like Ruttan and Smead, have devotedly worked to make furnace heating successful.

At this point I am impressed strongly with the fact that of all the literature in the world, how few works, after all, represent all human culture, the flower of all the rest ; the mass is necessary that these flowers of culture should exist, but we can never find time to plod through the mass. It is the same with the literature of the arts. If we take general literature, we find a few names that concentrate all human culture.

If we take the literature of the art of heating, we find it practically commences with Buchanan, is carried forward by Hood, and is now represented by Baldwin. The art of ventilating commences with Tredgold, is carried forward by Dr. Reid, and is now represented by Billings. Taking the 19th Century, we have Buchanan and Tredgold representing the early period, and Reid and Hood representing the middle period, and Baldwin and Billings representing the later period. The work of all the others is practically concentrated in these.

The natural evolution of heating and ventilating commences with a flat fire on the hearth, then the chimney flue is added, then the fire is held in a grate, then the fire is separated from the flue in a stove, then follows the hot air stove or cockle, then the hot water and steam heaters, then, as conditions get more complex, follows the fan blower. (Hot blast heating has been influenced largely from two directions, the piping from furnace work, and the iron cased heater from the hot blast dryer. Modern American plenum ventilation is largely influenced by Ruttan and the lumber dryers.) At all of the main points of the evolution you have variations and peculiar combinations, such as the ventilating grate and the numerous forms of fire places, and the many arrangements of stoves and furnaces. Steam and hot water are so nearly identical for domestic heating that they can almost be considered the same thing. That steam heating developed before hot water, both in England and in this country (seeming to interfere with the natural order), is entirely due to the extensive use of steam for power and the development of wrought iron pipe. It must not be forgotten that if

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steam had never been used for power it would probably have developed just the same for heating purposes, and that if wrought iron pipe had never been invented it would not have made one particle of difference in the development of steam and hot water heating; cast iron or some other material would have been used; of course the statement "if it never had been invented" needs qualification. Those who invented it had no difficulty in doing so; the material to do it was ready at their hands and there was a demand for the article, but that present-day English steam piping is largely cast iron and copper, and present-day American steam piping is largely wrought iron or steel, is due to the peculiar development of the mechanical arts in both places. It is peculiar that the firm of Boulton & Watt should be so closely identified with early heating and ventilating, as well as steam and gas engineering, but this can be accounted for by the fact that they were probably the largest and most enterprising firm of engineers in the world. Watt was familiar with most of the modern languages of Europe, and, like all inventors, was in touch with everything new in his special field; but after all he was only the enterprising inventor that we have always with us, who is continually looking up patent reports and information of every description for the purpose of monopolizing some industry that, without his bee-like activity, would develop just the same naturally.

In the year 1844 Dr. David Boswell Reid published, at Glasgow, his illustrations of the theory and practice of ventilation, with remarks on warming. This work is based on Tredgold, stimulated by the agitation then going on in England on the ventilation of the Houses of Parliament. Tredgold and Buchanan were civil engineers. Reid marks the beginning of a new era, a strong agitation for pure air. His work, I believe, is the practical basis of all the literature that has grown up around the subject of ventilation, and also the basis of all the forms of blower and fan wheels for ventilating purposes produced by American and English inventors. It has been largely used as a guide and reference book, until recently superseded by the work of Dr. Billings. Judged by his work he was a broad, humane, and progressive man (see Buchan). He died in Washington during the Civil War, while engaged in ventilating the federal hospitals. The first thing that strikes you in Reid's work is that it seems to be the basis for much of the matter in all modern essays on sanitation, hot blast heating, and the use of fans and ventilation. Here is where the catalogue maker, the original inventor, and the thesis compiler, have had their gold mine. They have worked him well. Here the architectural expert

has found his brilliant ideas, and, becoming a pseudo-adept in heating and ventilating, has become that worst of all professional men, one who never realizes the need of specialists, who puts up buildings of one idea for ventilation only and an eye-sore and mind-sore for every other purpose, like the Pension building at Washington, of which General Sheridan said that it was such an overwhelming pity that it was fire proof. True, the days of this genus seems to be over, but specimens bob up serenely now and then. Sometimes it is the heating engineer who becomes an architect and builds a school house around ventilating flues—the most horrible abomination of all. To any one interested in the ventilation of ships Dr. Reid's work is still indispensable, and on hot water heating it is still valuable. Charles Hood's practical treatise on warming by hot water, published in 1844, gave all the necessary technical information for erecting hot water apparatus of every description ; it supplements Doctor Reid's work, and became the practical text book on hot water heating of the Fifties and Sixties. All Canadian hot water practice was built on Hood's work ; its basis, of course, was Bramah's treatise on hot water, published as an appendix to Tredgold's work in 1836. A new edition of Hood's work has been published in England this year (1894), edited by F. Dye, making the sixth or seventh edition since 1846, which is the best testimony to the practical value of the work. Bernan's "History and Art of Warming" was published in London in 1845. It is a very complete work, and describes fully all the peculiar stoves, fire places, and cockles of the Continent. In 1846 Morrill Wyman published his Practical Treatise on Ventilation at Boston. It is an excellent work, and has had considerable influence on American ventilation. In 1848 Dr. Luther V. Bell published his annual address, delivered before the Massachusetts Medical Society at Boston, on a practical method of ventilation, with an appendix on warming by steam and water. In 1850 Robert Scott Burns published a large treatise on ventilation at Edinburgh, so that at the middle of the century there were no lack of works on ventilation.

Warming and Ventilation, by Chas. Tomlinson, London, 1850, (second edition 1858, third edition 1864, and ninth edition 1886), is a valuable work in many respects, as it covers a great deal of Buchanan's and Tredgold's works, and is particularly full on early fire places and their histories ; but the later editions should have been corrected with foot notes. The number of editions published shows that it was considered in the Fifties and Sixties a valuable work ; next to Hood's and Dr. Reid's it is the best work of the middle of the century. The one great defect of it is that the au-

thor is rather insular in his make up ; he knows the past well, but in 1864, when he wrote his last preface, he either knew nothing of contemporary steam heating or in his immediate environment steam heating was in a very bad way, being, as he says, just where Boulton & Watt left it.

For those who cannot have access to Buchanan's or Tredgold's work, Tomlinson's is the best to commence with. It also covers practically all of Bernan's great history of the art of warming. Whoever in the future proposes to write on heating and ventilating as a combined art should consider the arrangement of this work very carefully, as it could readily be made the basis of the best work that has ever been published on the subject. If there is ever a cyclopedia or dictionary of heating and ventilating published, Tomlinson should furnish the basis for it.

I must make a digression here to call attention to the valuable papers read by A. C. Walworth at the 1892 and 1893 Conventions of the Master Steam Fitters. They throw a valuable light, or side light, not only on the art of heating and ventilation, but on the literature of it at the middle of the century. I am very skeptical myself about much of the art originating (even of American practice) in the shops of Walworth and Nason, but I am skeptical on general principles, as there was not much originality required. The progress of the co-related arts of steam engineering and much of machine shop practice would account for the various improvements. There is no question that Walworth and Nason did the bulk of the American business in the early days here, and Mr. Walworth's able paper posseses peculiar value for that reason.

In 1862 Robert Ritchie published a treatise on ventilation at London, and Henry Ruttan published his treatise on ventilation and warming in the same year in the United States ; and in 1864, an American Edition of Dr. Reid's work was published, edited by Dr. Harris, on heating American homes. Dr. Reid had published previously some new matter on ventilation in 1858. In 1868 was published Lewis W. Leeds' great work on ventilation ; extravagant and erratic as it is in many parts, it forms the basis of a great deal of American practice in ventilation. Leeds advocated direct radiation and downward ventilation, the incoming air comparatively cold. He arrived at these theories by having tried indirect radiation with high temperature hot water heating, and finding that the air was uncomfortably over-heated he went to the other extreme. His work, like the work of all theorists, was, I imagine, largely failure. Whether he had greater success on the other side I do not know, but his work is valuable as showing how not to do it, and I believe

marks an important epoch in the art of ventilating buildings. The world owes a good deal more to the failures of the world than to the successes, because everything the world holds dear came through failure first. There had to be experiments. As Emerson says, the spheres rise by falling, and there could be no success without failure. "But convected heat (hot air) is the great curse of the American people." Leeds, page 105.

"Nearly all animals except man secure this condition by building their houses or burrowing below the ground so that the warmth of their bodies causes the foul air to flow out while the cool fresh air to supply its place must come in from above and consequently fall upon their heads first." Leeds, page 107.

At this period, 1865 to 1875, Gen. Morin in France, and Capt. Douglas Galton in England, were very active in the propaganda of ventilation. Their works can be found in the proceedings of the various scientific societies; they have had great influence on the literature of this subject.

At this time there was not a periodical in the world that devoted any part of its space regularly to heating or ventilating, nor was there much, if any, circulation of books or literature on the subject among those engaged in the industry here.

The catalogues of a few manufacturers such as Morris, Tasker & Co., and the pocket-books such as Haswell's, with the general literature of steam engineering furnished almost the whole literature used by the trade. This particular period was not one of much advance or much improvement, but it just precedes a period of great activity and improvement; in fact, Leeds' theories of direct radiation were having much influence. There was plenty of indirect work being done in private houses and public institutions, and some blower work. I remember that in fitting up the school annex to the Philadelphia Blind Asylum in 1872, where I was employed as a steam fitter's helper, that the work was entirely direct radiation, a great many of the radiators being made on the ground, return bend pipe pattern. There were large ventilating flues at the ends of the corridors, having steam coils of rectangular patterns at their base, so arranged as not to obstruct the flue, but in the rooms no special inlets for air were provided, and the water closets were ventilated by chimneys having steam coils at their base, in the same manner.

There were several books, essays, and catalogues published in the period between 1873 and 1883. With the exception of Rafter's "Mechanics of Ventilation" I do not think they had very much influence on the arts of heating and ventilating, but in 1883 was published Baldwin's steam heating for buildings, and about the same

time, or shortly after, was published Robert Briggs' "American Practice in Warming Buildings by Steam," Baldwin's work is one of the best books that has ever been published on any art, and its influence on present American practice predominates over every other influence. It is a book for workers, written by a worker who thoroughly understands what he is writing about, and is not afraid his subject will get away from him.

No World's Fair represents the industries of any people up to date ; it represents the average up to the time ; that is all. The advanced workers are generally disappointed at a World's Fair. They know lots of new things better than those shown. It is the same with books ; they represent the average of good practice up to date ; usually a little more than that, but they do not represent the latest things ; they can't in the nature of things. Baldwin does not realize that shell boilers are almost obsolete and practicaly superseded by the water tube ; that the single pipe system is dominating the whole West, and soon will be the whole East ; that wrought iron tube radiaton is doomed ; that hot blast heating is about to do all the ventilating. He is totally oblivious to these changes that are going on all around him. (When I refer to single pipe systems here I mean the continuous main system with upward distribution.) He has never heard apparently of the Williames system, or the Osborne system,, but in everything that goes to make up the practical details of work as practiced now in New York city, and as will be practiced for a good many years to come, his work is complete and perfect. He has never considered the heating and ventilating of the skyscraper, whether office building or apartment house ; his risers do not go up many stories, but then, no one so far has done anything to ventilate the skyscraper, and the heating of them is a simple problem, because they are always well built. For gravity circulation and for ordinary low pressure work, and for a great many details of large work, Baldwin is complete, but where the large work goes into and merges, as it very often does, into the problem of steam engineering, Baldwin's work falls short of the best practice of the best steam heating houses. In 1894 the thirteenth edition of Baldwin's Steam Heating was published, with many additions.

Of Robert Briggs' work, ,and the able discussion that it evoked, too much cannot be said in praise. In this discussion Sir Frederick Bramwell described a block of four large buildings heated by hot water, in which the circulation was kept up by a pump—a very ingenious arrangement. Sir Douglas Galton refers to the same system in his article "Heating" in the Encyclopedia Britannica. An engineer, who shall be nameless, must have thought well of the

main idea of this system, for he patented it a few years ago, several years after a description of it was published in the mechanical papers. It is very interesting to read the comments of Messrs. Geneste & Herscher, the French engineers, on this paper, published in the discussion. They state that there could be no good results unless each radiator had a separate steam trap, and also that there should be a separate steam trap at the bottom of each riser, ascending and descending. These comments show that in pipe work the French are very much behind the times ; their ideas on ventilation are much better.

In Messrs. Geneste and Herscher's opinion, it was always desirable to aim at a process which would consist in compensating the loss of heat through walls and windows by local radiators placed in the apartments in such a way that the air introduced for ventilation should not be heated above the degree suitable for respiration. Had the matters been referred to in Mr. Briggs' paper, they would have had something to say on the disposition of the air-supply and of the admission of heated air into the apartments.

Messrs. Geneste & Herscher go on to say, while acknowledging the thoroughly practical character of Mr. Briggs' paper, that they deprecated the far too secondary position to which he had relegated the system of ventilation with warmed air, combined with local heat radiators, which they considered to be the one most conducive to comfort and to economy. They always employed that system themselves where possible, and, except in the cases of public halls, theatres, and such buildings, were always careful to place the local radiators in contiguity with the coldest wall. But they must add that they passed over these surfaces a certain volume of air taken directly from outside, that was to say, having only had to traverse the thickness of the wall, this amount of air being calculated so as to produce a convenient ventilation in proportion to the use to which the apartments were put, and the number of their occupants. The amount of heating surface was itself calculated so as to impart to that air the temperature most convenient for respiration, and to radiate into the apartment air at the desired temperature. That temperature could be maintained as high as was desirable in a habitation. They considered that it was not well to give the air, when introduced, a temperature too high, for in that case it tended to ascend at once from the radiators to a height above that where it was needed for respiration ; that was to say, they preferred that the air should at once reach the upper parts of the room, to descend when it had been mixed with the vitiated stratum at the top. The practical means of meeting this difficulty was to divide the radiator

by a partition, so that one part was devoted to warming the fresh air introduced, while the other radiated the heat into the apartment.

The disposition of the heating surface along and below the coldest partitions, and notably the windows, had the effect of preventing descending currents of cold air, which always existed in contiguity with cold partitions. These currents were not only a source of discomfort to indivduals, but interfered with the proper circulation of the air by promoting a flow of vitiated air in their neighborhood. It was, of course, understood that a general system of ventilation must provide for the outlet of the vitiated air, which was effected by partial openings communicating with one or more collecting conduits having access to exhausting chimneys, in which it might be desirable to place a heating coil or a gas burner, in order to promote an upward draught. In public halls or apartments of some extent, destined to contain a large number of persons, they effected ventilation by a blower causing the air to pass over radiators ; but even in such cases they employed, if possible, local radiators as well. They entirely approved of Mr. Briggs' system of re-heating the air by passing it through an auxiliary coil before letting it circulate in the airways. It would be conceived that this mode of heating by local radiators involved a large division of the steam pipes ; it was, therefore, all the more important that special precautions should be taken to avoid escapes of steam or irritating noises. It was also necessary to assure for this disposition all the advantages it offered of rendering the different heating surfaces independent of one another, so that the temperature of any apartment could be modified at will. The system of distributing the steam they had described perfectly fulfilled these conditions, and gave the best results.

It is unfortunate that in the American edition (which I believe is the only one that has been published) of Robert Briggs' Steam Heating, second edition revised, with additions by A. R. Wolf, that the able discussion of that paper by such men as Sir Frederick Bramwell, Sir Douglas Galton, Chas. Hood, Sir Wm. Armstrong, Lewis W. Leeds, Arthur Riggs, and other able and well known engineers has been omitted and a number of tables of data of no particular value, or at least not exceedingly valuable, have been published in the place of the discussion.

It is interesting to know that Mr. Lewis W. Leeds, Capt. Galton, and Chas. Hood were present when Mr. Briggs' paper was read.

I will summarize Mr. Hood's remarks : He observed that all that was mentioned in the paper as being new in America had been both fuller and better stated by Buchanan and by Tredgold. The processes described by Mr. Briggs had been practiced extensively

for the last 50 or 60 years in England to Mr. Hood's personal knowledge. Steam heating on a very large scale had been successfully used for several years by Loddiges, of Hackney, commencing in the year 1819, and had never ceased to be used since that time precisely as the author described it as a new invention in America. There is a mean or compromise line between Briggs, Walworth, and Hood in their various statements ; they each have truth with some errors.

About 1875 Gen. Arthur Morin published another of his numerous papers in which he unhesitatingly condemned the Perkins' system of heating because of the high temperature of the pipes. At this period the plans and specifications of the Treasury Department of the U. S. Government (more correctly the supervising architects' office) furnished a heating and ventilating literature of their own.

A collection of these specifications, printed in book form and published for the trade, would be the best record of American ventilation at this period. I will note here that since 1880 there has been more literature published on the subject of ventilation than in the previous 100 years, but to return to Dr. Billings' work, I would advise any one beginning the study of heating and ventilating to commence with his book.

Buckle lays down the general rule that the later works on physics and mathematics are generally the best, while in heating and ventilation there are too many exceptions to this rule. There can be no mistake made in commencing with Billings ; then get Baldwin ; then Hood and Dr. Reid, and then Tredgold and Buchanan, or, in place of the four last mentioned, get Tomlinson. That is the skeleton : you can fill it in with everything that comes along after that. There is one thing the reader should be on his guard against, that is the tendency of Dr. Billings, and a great many others besides, to be somewhat afraid of mechanical propulsion ; it is so much simpler to have a fire or a steam or hot water coil at the base of a flue, so that skilled labor can be dispensed with. I am now referring to the first edition of Dr. Billings' work. This is exactly the same tendency that leads to preferring a furnace to a steam or hot water heater and is, as I have before remarked, philosophically wrong. As a matter of fact, ventilation that is not mechanical, except in very small buildings, is hardly worthy of the name. A large list can be made from Dr. Billings' work, of papers and data published on the subject of heating and ventilation from time to time, and in the description of practical work executed it excels every other work ever printed on the subject. In the new work, printed

in 1893, nearly double the size of the old one, Dr. Billings has added ten years' practical development of heating and ventilating to the former work. The chapter on the literature of heating and ventilating in Dr. Billings' new work is very valuable.

In 1886 was published Schuman's Manual of Heating and Ventilation. This book does not seem to have been written because the author had a message to deliver, as Carlyle says, but rather, I should judge, because he was requested to write it. It is very Weisbachish and the engineer who is thoroughly familiar with Kant, Hegel, and Schelling will probably be delighted with its abstractions. This work represents the practice of the art by men who are not exclusive specialists, and in environments where there is not enough heating and ventilating done to create a special calling. It assumes to represent American practice, that is, it is published as an American book, and that would be the natural inference. I will venture to say that the author had very little connection with the special industry of American heating and ventilating.

I have now reached our own period and from this forward I will try and condense, as much as possible, what I have to say, and as no man is a good judge of the tendencies of his own times, I should perhaps say the activities of his own time, I will ask you to bear that fact in mind, and not accuse me of error, when I am sure I cannot help making some mistakes in judging my own immediate period and surroundings.

I mention in the list of books several works published in this period that I will have to pass by without much or any comment. In 1890, John H. Mills published his large work on heat and its application to the warming and ventilating of buildings. Mr. Mills gives a great deal of space to subjects that strictly belong to chemistry, thermo-dynamics, and steam engineering. He has spent a lifetime in the heating business, and his work is the result of his experience. He has advocated the use of high temperature water heating apparatus on the Perkins' principle, but with overhead mains and downward distribution, having only one riser for supply, and return—a modification of his ovehead downward distribution single-pipe two-valve steam system—a system of piping now used in many places in the West for steam, with one valve only. His hot water returns from the radiator to the same riser that it takes its supply from. It is hardly likely that Mr. Mills' system of piping for hot water will ever get wide application, as the class of buildings it is best adapted to, and where there would be some object in using it (high office buildings), will be in the future generally heated by steam, until probably superceded by electric heating. Hot water heating,

outside of small building work and green-houses, will hardly get much wider application in this country. The value of Mr. Mills' work is somewhat impaired by the advocacy of special methods and appliances, some of them of an advertising character.

Mr. Mills, following Dr. Reid, has called attention to the great loss of power by running small disk fans fast, instead of using large fans and running them slowly ; but there is a good deal more than this where large quantities of air are to be moved, and, in fact, if our art was very refined, this would apply to comparatively small quantities of air. There is only one right way to remove air, and that is by a positive blower or an air pump. The trouble with the positive blower is that it is designed specially for pressure work such as foundry and pneumatic service. Volume machines, with aluminum skeleton pistons and sheet iron casings, can be designed that will displace the fan. I am aware that a positive blower to move 30,000 cubic feet per minute costs, say, $6,000, while a fan to do the same work can be bought for much less than six hundred dollars. It is true that in mine ventilation, where the magnitude is great and the experience has been large, they use the fan 36 to 48 feet in diameter, and 12-foot face, moving from 300,000 to 500,000 cubic feet of air per minute ; but it is also true that until recently mine ventilation was by aspirating shafts, with fire at the base to create the current. This marks the first stage in all ventilation ; the second stage is the fan, and the third stage in the evolution is the positive blower or air pump, the latter doing its work with one-half the power of the fan and one-quarter the power of the ventilating flue using a fire at the base.

The present day literature of heating and ventilating is well represented in the ninth edition of the Encyclopedia Britannica. The article on "Heating" by Sir Douglas Galton, and the article on "Ventilation" by Prof. Ewing are of a very high standard.

I quote the following extract from Prof. J. A. Ewing :

"Good recent examples of positive plenum ventilation are to be found in Dundee University College, and in a number of schools in Dundee and Aberdeen, where the arrangements have been designed by Mr. W. Cunningham. Some of these are ordinary double acting reciprocating pumps, driven generally by water engines. The pumps are rectangular wooden boxes, stiffened by iron ribs, and provided at top and bottom with inlet valves, consisting of a number of short waterproof cloth flaps working against a vertical wooden grid ; the piston, which is also of wood, has a vertical travel ; it is held in place and worked by wire ropes above and below, which lead over pulleys to the water motor, and the piston is balanced by a counter-

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weight in the descending branch of the upper ropes. A piston 5 feet square, with a stroke of 5 feet, works at 20 strokes per minute, and delivers 150,000 cubic feet per hour.

"In other instances where the volume of air is greater than could easily be dealt with by common pumps, Mr. Cunningham uses revolving pumps of the Root blower type. At the Dundee College a battery of five of these blowers, each discharging over 150,000 cubic feet of air per hour, is driven easily by a gas engine of two horse-power. The rooms are heated by having coils of Perkins' high pressure hot water pipes in the main distributing flues. The inlets are flat upright tubes extending up the side walls to a height of nearly 6 feet, and open at the top. Ample proof of the advantage that results from giving a vertical direction to the entering current is supplied by the success of Mr. Cunningham's arrangements. Where this form of inlet is exclusively adopted, alternative outlets are generally provided in the end walls : one group near the ceiling ; another a few feet from the floor. They are fitted with doors which allow one or the other to be closed. The high level outlets are used in warm weather, when the fresh air that comes in is comparatively cool. The low level ones are used in cold weather, when the fresh air, having been heated before it enters, would tend to rise and pass out too directly if the outlets near the ceiling were open. The outlet shafts communicate with a louvred tower or turret on the roof. Each room receives a volume of air equal to its cubic capacity in about 12 minutes, so that the atmosphere is completely changed five times in an hour. The inlets are proportioned to do this without allowing the velocity with which the air enters to exceed 6 feet per second." I wish to call particular attention to Prof. Ewing's statement that a two horse-power gas engine runs five air pumps on the Root principle at Dundee College, each air pump delivering 150,000 cubic feet of air per hour. With disk fans, if they could be used for such work, my opinion is that the power required would be 100 per cent greater, and with fan blowers 150 per cent greater. Prof. Ewing calls aspirating chimneys mechanical ventilation ; so does Schuman. I think the term should be restricted to ventilation by machinery.

A recent work published in London is W. P. Buchan's Ventilation, 1891, most complete on all forms of ventilating outlets and cowls. The author says in the preface that a cheap and popular illustrated practical work on ventilation which would be useful alike to the architect, the physician, and the artisan, as well as interesting and instructive to the general reader, has been much desiderated. (Well, may be it has, I don't know.)

I will quote from Mr. Buchan's work, page 69 :

" The styles of ventilation we have been describing belong to the atmospheric, wind-acting, or automatic systems. It so happens that Professor Carnelley, F.C.S., Professor of Chemistry in the University of Aberdeen, has been lately engaged examining the air of a large number of schools in England and Scotland, and as the result of his examinations has asserted that the air in all the automatically ventilated ones was bad, and therefore all schools ought to be ventilated by mechanical means. Now, if the automatically ventilated schools examined and referred to had their ventilation carried out in some of the foolish, inadequate, and bad styles hereinbefore described, and condemned in chapters V and VI, it is no wonder Professor Carnelley should have found the air in them to be very bad, and most unwholesome, both for the teachers and the pupils. (Mr. Buchan's work is used to advertise his own contrivances, a patent exhaust cowl and a patent exit valve to prevent down draughts. His work is very full on Tobin tubes and Sherringham air inlets and methods of direct-indirect hot water work, and many other things that are peculiarly British, and some of them decidedly objectionable. It must be admitted, however, that the Scotch and English method of giving some ventilation by direct-indirect is much better than giving no ventilation at all, which is the practice of most of our large suburban schools and colleges.)

"Some of the large city schools are two or more stories in height, and serve for from 1,000 to 1,500, or more, scholars, while many of the country schools are only for about 700 or less.

"To force small country schools of only one story to adopt a mechanical system of ventilation would be a hardship, owing to the first and continuous expense, and is not necessary.

" The Blairgowrie school serves for about 600 pupils. It stands on high ground, well exposed to the wind and fresh air. The ceilings are about 19 feet high. The ventilation was improved in June, 1886, on the plan for outlets in Fig. 47, and with Tobin's tubes for inlets. Were the work to be done now, I would recommend the provision for outlet ventilation, that is, the size of the outlet pipes and ventilators to be larger than was supplied in 1886. Possibly an improvement in this direction may yet be effected, if considered necessary, by changing the position of some of the present ventilators and pipes, and putting up a couple or so of new large size ventilators, with pipes to suit. As the school is, however, it is an immense improvement upon what it was previous to May, 1886. I think mechanical ventilation would be quite superfluous here. The school rooms are heated by low pressure hot-

water pipes. Heating by large hot water pipes (low pressure) is the most generally used method, and the best."

I understand the system of heating and ventilating that Mr. Buchan recommends, when he is not recommending his own automatic cowls, is direct indirect hot water, with natural ventilation for the outlets, and for very large schools he recommends mechanical ventilation.

It would be too severe to say that Mr. Buchan's book represents the worst English practice of to-day, but I think it perfectly fair to say that it represents the present amateur practice of heating and ventilating in Great Britain, and that Mr. David M. Nesbit's paper, read at the 1894 Convention of the Master Steam and Hot Water Fitters' Association of the United States, and Prof. Ewing's and Capt. Galton's articles in the Encyclopedia Britannica represent the best professional practice there. The present new development of architecture is the high office and apartment-house building, the class of buildings developed by the elevator. This is all that there is new in modern architecture—this building, and the problems that grow out of it. These buildings are so new that the architects quietly ignore the ventilating altogether. I am writing this in one of the finest office buildings in New York city, designed by one of the best firms of American architects, and there is not a particle of ventilation in this room or any opportunity for it except through the windows and door transoms, which is no ventilation at all. The water closets, or toilet rooms, are fitted with registers connected to what are supposed to be ventilating flues, but the smell of the toilet rooms when the closets are occupied is staggering. Now, this building is owned by a large corporation that has a special engineer and architect of its own, and should be well ventilated. But all the high office buildings in the city are in about the same condition—abundance of heat, but poor ventilation ; and the apartment houses are no better—I mean the sky-scrapers.

I am sorry that I have to close this review of our art with what seems to be faultfinding, but I realize fully that tone is entirely wrong. The fault, if there is fault in anybody, is not with the constructors of the new architecture ; it is with ourselves we should find fault. The one way to cure this thing is to amend the building laws, compelling a certain amount of ventilation to every office, and in every room in the high buildings, the same as light and sanitation are now regulated by law. Our work now, at the close of the 19th century and the beginning of the 20th, is " compulsory ventilation."

It is now recognized that heat, light, motion, force, and electricity, are manifestations of the same thing ; the new literature of

heating and ventilating will concern itself with electric heating and ventilating devices in connection, perhaps, with gas heating, and new applications of gas and electricity will add to the complexity of heating and ventilating ; but the line of application will probably be in applying gas to heating water and using electric regulators and motors, in connection with blowers, water heaters, and steam generators used exclusively for heating. The new literature will have to consider gas and electricity in addition to water, steam, and air of the old literature. The old fire-place literature is in Bernan and in Tomlinson's works. The new literature is in the trade press. The art of heating and ventilating extends from one to the other across many centuries.

In the list of papers which I give as devoted to the arts of heating and ventilating, two of them make it an exclusive specialty, three others not exclusively devoted to this special industry, have articles of importance regularly every issue, in a special department, so that to-day the art has a rapidly growing literature.

Of the works of our own time, or rather of the works of to-day such as Baldwin's Hot Water Heating, Steam Heating Problems, and the Metal Worker's essays, I can only say that they should be in every engineer's library, with bound volumes of all of the trade press and all of the excellent trade catalogues, and particularly English catalogues, where they can be secured ; all of these, properly card catalogued and indexed, should also be in all our public libraries.

I started out to trace the evolution of heating and ventilating literature, showing the development of modern heating and ventilating and covering its history for one hundred years. I may have made too many digressions from the literature to the arts, but as in my mind, the art and the literature are one, I could not treat it in any other way. There has been a natural evolving and unfolding of the art and its literature and no detached growth at any point in the development. The men engaged in the industry to-day are the natural successors of Green and Hoyle and Buchanan and those who preceded them, and the unity of this succession is clearly established by the history of heating and ventilating literature.

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IX.

THE HEATING AND VENTILATING ENGINEER—A COMMERCIAL VIEW.

BY STEWART A. JELLETT, PHILADELPHIA.

(Member of the Society.)

I was much interested in a recent editorial in an English paper, on the subject of "Professional Fortunes," which the writer opened by advising all young men starting out to make their fortunes "to avoid the service of the State and all the professions alike." He then contrasted the fortunes made in trade with those of high and able offices of the Crown and the leading members in the professions of the church, medicine, law, and engineering.

The article is written from an English point of view, but it applies with equal force to us. Few, if any, of the great American fortunes have been made by professional men, and I have no knowledge of any among those engaged in our branch of engineering. Possibly I underrate the wealth of my fellow members.

The tendency in trade over the civilized world to-day seems to be downward. In some foreign countries it has apparently reached a starvation basis, from which there is as yet no prospect of relief. In America I regret to see the same tendency in the increased numbers of the unemployed in our large cities, due, in a great measure, to unrestricted immigration, and the gradual reductions made in the price of goods, and, it follows, in the cost of producing them.

The maximum of quality or results for the minimum of cost is the demand of the buyer, and the manufacturer is striving to meet the conditions by improved machinery, systematized processes, and reduced wages and profits. The merchant is meeting the problem better by the enormous growth in the scale of everything in which business can be done. The world is his market and the printing press his salesman.

Changes in the methods of doing business enable him to carry his trade mainly on credit. I question if, in any legitimate business to-day, the margin of profit is as great as 20 years back, but

where the enterprising merchant of that time had 100 customers, his successor of to-day has 1,000. It is the magnitude and multiplications possible in trade, and the rapid receipt and delivery of goods, enabling four to five times the volume of business to be done on a given capital, that accounts for present day mercantile fortunes.

This advantage in scale is entirely wanting to the professional man, as his business requires him (at least to a great extent) to come in personal contact with his customers, and there are but ten hours in a hard worked day. If he be a doctor, he must listen to the plaints of his patients, if a lawyer to the woes of his client, or if an engineer to the needs of his customers, or the troubles of his contractors, all of which involve time. If these matters are delegated to assistants entirely, he loses custom, and with custom, income. It is unfair that this condition of things should exist. The engineer who has devoted years of careful study and thought to perfecting himself in his profession should be, and is, in all fairness, entitled to the same returns with his brother merchant of equal ability. It is true, however, that the phrase "For professional service rendered" on a bill has to many men a different sound from that of "To merchandise furnished."

It is with the thought of improving the commercial position of the heating and ventilating engineer that I submit this sketch for your consideration, trusting that it will open a discussion that will point the way to improvement. "We cannot make headway as individuals; we can only make headway by acting as a body."

And it is by correcting the existing abuses that I believe we can make most headway at present. The broad motto of the business world is the "Maximum of business at the minimum of expense." Let us apply this to our branch of trade, thoughtfully, considering the many unbusinesslike methods that have been allowed to take root and grow. Should it not in our case be reversed, the maximum of expense for the minimum of business? I think so, and I believe that you will agree with me when you consider the matter in detail.

The adage "Competition is the life of trade" is capable of misinterpretation. Competition can overreach itself and become the death of trade, and unregulated competition is to-day the bane of many branches of engineering, and particularly our own. I quote from the Bulletin of the National Association of Builders: "While we are all competitors, and sometimes sharp competitors, we should still stand firmly together for the correction of errors in practice and in principles of action."

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The business of heating and ventilating as carried on to-day is capable of three divisions :

1. The engineer who plans and supervises only.
2. The engineer who contracts only.
3. The engineer who does both.

The first is dependent wholly for his income from fees received for services, and he is consequently affected by the business methods of the third, who plans as well as contracts. The second looks solely to the profits of his contracts for his remuneration, while the business of the third, if rightly conducted, should pay a profit in each division. Let us now consider the abuses that most need correction. I would place first of all the practice of making plans and specifications for architects and owners free of expense to them. The committee who drew our constitution were impressed with the necessity of correcting this (see article 1, subdivision 8), "to establish a uniform scale of prices for all professional services."

The scale is nearly uniform now, I regret to say, but, like the winds of Heaven, uniformly free to all. I have heard contracting engineers say that this custom has obtained such a firm hold that to refuse to render such services free would kill their contracting business. You can all readily see the effect of such an unbusiness-like practice. It largely kills the business of the consulting engineer and takes a large part of the legitimate profits made in contract work to meet the expense of making these plans and specifications.

Many of our architects have one or two concerns to whom they send their building plans regularly to have the heating and ventilating and power systems carefully worked out, but with no thought of paying for such services. There is no sound reason why this abuse should not be at once corrected, and there are good reasons why it should be.

First, It is unfair to the consulting engineer, who manifestly cannot render such services free.

Second, It is unjust to the general customers of the contracting engineer who does it, as the expense of doing it must come from the work done for them, and for which they are paying.

Third, It places the architect who accepts such gratuitous services in a position to be justly criticised, as he must either be unfair to the engineer from whom he accepts such service, for which he himself is being paid, or he must be unjust to his client if the acceptance of such service affects his judgment in deciding the award of contracts for the work.

Fourth, It is not business, viewed from any standpoint, and is

unjustifiable. Let us, therefore, not adjourn this our first annual meeting until we have taken the necessary steps for an immediate and radical change in this department.

The present forms of specifications we are asked to bid on, and the contracts presented for our signatures, are also a proper subject for your just criticism. There are many specifications handed us for estimates which do not describe in any complete manner the work to be done, but this slight oversight is taken care of, so far as the owner is concerned, by some such clause as this: "The material and workmanship throughout must be entirely satisfactory to the owner and the architect, and the system must be guaranteed in every respect to do the work asked for to their satisfaction." I would advise all our members not to sign a contract with the word satisfactory in it. I hold that what cannot be defined or accurately stated should be left out of the specifications.

Who can estimate what it will cost to do anything to another man's satisfaction, one whom possibly he does not know? It came into use in the days when heating was largely a matter of faith in the party employed to do the work, and when there was no general or definite knowledge of the subject. It is the outgrowth of methods that do not exist to-day, and its use should be dropped. The buyer should be required to decide whether the thing he is asking you to do, when done as specified, will be satisfactory to him or not.

Another relic of the days of faith in the heating business is the clause requiring a guarantee of temperature. You have doubtless all read the interesting correspondence on this subject in an engineering journal published in New York in answer to a letter written them by one of my partners. It will not, therefore, be necessary to enlarge on this subject. But why, I would ask, should a contractor, when asked to bid on a definite amount of heating surface and boiler, located exactly on a plan, sizes of pipes, etc., being given, and the character, exposure, and use of the building, better known to the maker of these specifications than to himself, be asked to guarantee the result? The contractor is asked to insure the results of another's calculations, for which insurance he collects no premium, and for the practical determination of which guarantee he is often dependent on the employees of the owner. There is certainly no equity in this requirement, and the margins of profit on the labor and materials entering into the work do not justify the risk.

Our society should also protest strongly against the use of the inferior material that is now crowding the market and insist that

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the standard be raised, advising the use of such materials only as they can conscientiously recommend.

There are, no doubt, numerous other abuses, some local, others general, that need correction and that will be adjusted as we grow to appreciate more the benefits of our society. Those I have pointed out seem to me to first need attention. I will close by quoting from the Bulletin of the National Association of Builders, which is as applicable to our business as to that of the builder :

"The present custom of interpreting drawings and specifications is inherently unfair, notwithstanding the fact that many buildings are annually erected without serious difference between the contractor and the architect ; the contractor is allowed no voice in the settlement of questions that are of vital pecuniary interest to him. Contractors have always submitted to a large amount of injustice in the demands made upon them, but there is no good reason why they should continue to do so."

DISCUSSION.

Mr. Onderdonk:—I only have a few words to say with regard to this paper. I am in thorough accord with its sentiment. Ever since I have known anything about the steam heating business I have felt that the steam heating contractors and the steam heating engineers have been abused and have been asked to do large amounts of brain work without compensation; that they have had to bid against themselves and furnish their own plans, and I have endeavored, in another association of which I had the honor to be a member, to bring up this matter of compensation for plans and specifications, and it did not seem to be nearly as important as other subjects which were of much less importance to me. I do hope that this association will thoroughly discuss the theme of this paper and that we will arrive at some resolution that we will cease working for nothing, as engineers and contractors, or as contractors.

Mr. Barron:—I was going to ask Mr. Jellett how he would propose to cure the evil; but while I am here I will go a little farther than that and say that I do not think it can be cured. I think it is one of those things that you have got to bear; a thing that will grow away of itself. The only thing the contractor can do is to advise his friends who are architects to go to a consulting engineer when they come to him for a plan and specification. I am afraid there are a very few contractors who will do that. With the growth of consulting engineers in our large cities the contractor will be friendly, more or less, with the consulting engineer, and he

will advise the architect to employ the consulting engineer for that purpose. It is hardly possible to combine the two lines of business—the consulting engineer's and the contracting engineer's. A thing of this kind can only be changed by the natural evolution or growth of the consulting engineer in our large cities.

Mr. Jellett:—It is not often that I disagree with my friend Mr. Barron. But I certainly do in this case. I do not think it is impossible to correct it at all. Some three years ago in our own particular business (we are contracting engineers) we put on our cards "Consulting Engineers." We had been doing this class of work for nothing. We made up our minds to stop it. The result is that our engineering department last year made a larger percentage of profit than any other branch of our business. Architects have told me plainly that they did not expect to pay for plans, and I have told them as frankly in return that I did not expect to work for nothing. If we all took that position we would not be imposed upon. This last year I have kept five men at all times in the engineering department. Drawings for our work have cost us nothing. I have charged the entire expense of the drawing room to the engineering department, and even saddling that on and saddling on the entire expense of rent, because we had a separate draughting room for it, it has paid the largest margin of any branch of our business. We prepare plans and specifications and we also contract. But we have no agencies. We are entirely free to specify anything good that is in the market, and I think my competitors in Philadelphia will bear me out—we do not get too much of the work that we plan. My friend Mr. Onderdonk, I believe, has taken more of it than I have. But if we had not been paid for our plans and specifications there would have been that much charged to the debit side of profit and loss, which was not the case.

At the present time the work going on under our plans and superintendence amounts to some $400,000 worth. Now, for all of that, we are getting a reasonable fee. In the case of architects, we do not charge them the full commission, because they have to give us drawings and consult with us at different times, and are therefore entitled to a share of the fees. There is an increasing number of architects who are willing to pay for plans and appreciate what going into the details means. We plan not only heating and ventilation, but electric light plants as well. We take ice machines and elevators, and, in fact, complete mechanical installations. When we are working for an owner we charge him full commission. We are doing some work for a state institution. Their

architect rather opposed having us as consulting engineers at first. When he was told it would not come out of his commission he immediately withdrew his objections and now states he is very glad to work with a consulting engineer because it relieves him from a great deal of detail work, and the building when completed is giving such satisfactory service. Several architects for whom we have made plans have come to me and said that the building when finished has been so much more satisfactory than the ordinary haphazard way that they felt the expense was warranted. In one or two cases I have known the architects to go to the owners and ask for additional compensation for special engineering services. There is one building at the present time in which, although our fee comes from the architect, the architect is being paid an additional sum to cover special engineering services. This is paid over to us. The owner says I am getting the benefit of it and I should pay for it. So in this case the cost for the entire superintendence is coming from the owner. Now I think we should take a positive position in this matter and say as engineers that we will not work for nothing. It is not fair that the architect should ask us to plan a steam plant which costs $20,000 and on which he receives $1,000; it is not fair to ask us to do that for nothing. A well-known architect sent for me a year ago and said, "I want you to make a plan for this building." I said, "How do you want me to charge for it?" He said, "I do not expect to pay for it." I said, "Then I do not expect to do it. Do you make these plans for nothing?" He said, "No." "Then," I asked, "Why should I make your plans for nothing?" He said, "It is the custom." I said, "If it was the custom for architects to work for nothing would you conform to that custom? What right have you to ask me to do this for nothing? If I do this for nothing you are under obligations to me. If you are under obligations to me you are not acting in the interests of your client. You cannot serve the owner and me too. Now just stop and think of your position." The result was I got $600 to make his plan. I roughly calculated that the plant would cost $18,000, and I told him that I would make the plan for $600. Since then I have done other work for him and he says he feels warranted in paying for it. I think what one can do all can do. I know that other people in other states have done the same thing. I have talked with other men who have done it, and they tell me they have not lost by it.

We have a number of members who are consulting engineers only. They rely entirely on their fees for their income. Now, in all fairness to them, the members of our society who do both engineer-

ing and contracting work should uphold their hands, otherwise the growth of the legitimate engineering business will be retarded. As we come to educate the public in the best methods of heating, ventilating, and matters of that kind, just so fast will the business grow and reach a higher plane. It is the scramble for work without regard to how it is done that has let it down to where it is.

Major Light:—Some time since I sent in a topic for discussion. The secretary has just handed it to me, stating that it came in connection with the vote, and the letter was not opened until to-day. But this very question that is under discusssion was the question that I proposed. I have felt this thing very sensibly for a great many years, and certainly it is one of the most unjust conditions that can be imposed upon a professional man. A gentleman at Rochester, who is perhaps the most prominent architect in that city, would sometimes get puzzled a little and would not know just what was involved in what he wanted to do, and he would occasionally come down to my office and ask me certain questions. I would answer them, and he would go ahead with his plans and details, and yet he was continually paying other parties for his contracts ; but the other parties not being able to help him out in his dilemma, he would come to me. Now, in the state of Michigan, where my interest largely is at the present time, through the low order of the steam heating business, very few if any being skilled, it has been an open question with some engaged in that line of business whether it is prudent to continue to confine their efforts to that state, or whether it would not be better to move outside of the state.

I have taken the position in that state in the last three years that if men forming the Steam Fitters' Association would combine together and insit that all plans for extensive buildings should be prepared by some one man of known reputation and ability before they would bid on them, it would correct those conditions very quickly and exalt the profession. It is in that same line that I would make the suggestion here. In municipalities like New York, Rochester, or Boston, where we have more or less skilled engineers, it is an easy thing to select one, two, three, or four men of established reputation, and it might be arranged that all plans or details shall be prepared by some one or more of those persons at the option of the architects, and that the local organization. such as they have in many places, shall refuse to submit bids and propositions unless the plan was prepared by some skilled man. The topic that I proposed reads in this way: "The heating and ventilating engineer: his relation to the architect and his importance in connec-

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tion with detailed plans and specifications regarding heating and ventilation." The Chicago Herald has recently made quite a raid upon the architects and given an expose of the heating of their school buildings. The articles came out in three successive Monday morning editions, and on the 26th of last month they published an article condemning the present practice of heating and ventilating, claiming that it was a lost art, and it went on to speak of many abuses that have been developed in connection with the heating and ventilation of the school buildings and other public buildings in Chicago. I happened to see the article and I immediately answered it. I did not suppose that the answer I sent was published; but afterwards I learned that it had been published and had come to the knowledge of some persons there who were very glad I had answered it as I did. The position I took was simply this, that the effect grows out of the practice of taking the details and specifications of architects and the setting of work on those plans and specifications. Whereas if the plans and specifications had been prepared by skilled steam heating engineers in such cases there would have been a definiteness of result obtained to justify that method of procedure, and they would not have been at a loss for good results in their buildings. If we were to reach that condition in that way we would build up the heating and ventilating engineers.

Mr. Charles S. Hopkins:—This discussion brings up the same old question of the division of the spoils. It is how much of the wealth that is produced in our line shall go to ourselves as producers and how much shall go to somebody else who does not produce. I do not wish to be pessimistic or to diverge from the question, but I will say that we to-day are subject to the same iron law of wages that affects any line of employees or any department of labor. We work with our heads, if you please; we are skilled laborers, but we are still subject to this same iron law of wages, which is inevitable and unchangeable so long as the present condition of society remains as it is. We may make efforts to improve our conditions, and we may succeed in doing it to a limited extent in certain directions, but so long as there are 25 or 30 men endeavoring to get the same piece of work, just so long will we have to give more or less of our services for nothing, or rather to take a small percentage of the general wealth that is produced, and you cannot avoid it; you are between the upper and nether millstones.

Mr. J. J. Blackmore:—I think the evil exists. The question is how to deal with it. It is said that this meeting ought not to go

by without passing some resolution with a view to correcting this evil. I have suffered in common with others more or less from it. The only way we can cure it is, by constant agitation, to give our profession a dignity that at present it has not got, and until it has that dignity, and until we have the confidence in each other to stand by each other, we cannot do any good by passing resolutions. The discussion we have had here this afternoon will no doubt do good in bringing about a unanimity of feeling on the subject, but at the present time I do not think we can do more than pass a resolution setting forth that we shall use our every effort to bring about that state of feeling among engineers when they will insist on being paid for professional services.

Mr. Onderdonk:—The gentleman has just spoken about giving dignity to the profession. I want to indulge in a little personality with regard to that remark. Mr. Jellett and myself in early life were associated together, and we are now friendly competitors. We both do engineering and we both make plans. Mr. Jellett does rather more of it than we do. When he has made plans and put them in the hands of an architect, of course we recognize the head and hand at once. I have always made it a practice from the beginning until now to compliment them, to say that they were good and to say that I was delighted to estimate on them, and liked it much better than a rough and tumble, go-as-you-please arrangement, and the result is that both Mr. Jellett's plans and my own to-day, I think, are respected by the architects. If I make a plan for a building or Mr. Jellett makes a plan, it is concluded, and the building is heated that way. Only a few days ago a gentleman in Philadelphia, whom I have known since boyhood, and on whose knee I have sat many times, called me to his office and said: "Charley, I want you to go out to a certain home where I am interested, and I want you to give me a bid on the heating. Of course I would like you to get the work." It was in his power to give it to me as he was chairman of the committee, and what he says goes. I went out and looked the building over with him. I said to him, "You ought to have a central plant. Here you have seven or eight buildings with furnaces in. Put in a big plant, and there is the place to put it." He said, "That is a good idea; I would like you to give me a figure on it. Give me a figure on doing the work by hot water and by direct radiation and by the one-pipe system and the two-pipe system." I said, "All right." I went back to the office and the next day I called to see him. I said, "You probably don't appreciate the amount of labor you asked me to go into yesterday." He said, "I thought that was your business." I said, "Yes, but suppose I do not get the job. Don't you think it

would be fair to pay me for this work?" He said he thought it was and we arranged on the price there. So I went ahead and made out the plans to the best of my knowledge, went to the buildings, had them surveyed and went over the whole thing. We made a bid. One of our competitors went to him and said, "Onderdonk is all wrong ; he is off his base. Here is a plan just as good and it will cost only half the money." He got the job. I ask you did that man respect and dignify our profession by going to these people and saying that I was off my base, if I may use the expression. Mr. President, am I permitted?

The President :—It is pretty close.

Mr. Onderdonk :—I talked to the man myself a short time afterward and he described to me what he had done. He had put in an apparatus of just half the capacity that I had specified. They were just going to heat this one building this winter, but they were going to put in a boiler plant and pipe underground in the spring to heat the other buildings. He has hoodwinked them, and in the spring, when they come to do the other work, they will have to do that all over again. I do not blame him for getting the job, but I think he brought disgrace on the profession by doing it in that way. I think we ought to uphold each other. Sometimes plans are brought before me and I say I do not care to bid on them. But to ridicule anybody's plans because they are not your own does not dignify the profession.

Mr. E. P. Bates :—A few of the members here perhaps know my views very well. My experience has been possibly a little different from what has been related here, though perhaps in practice not essentially different. For a long term of years I have held to the view, which has been expressed, that we should be paid for the services which we render, even if the service is professional. It is just as much a service as it is to furnish material. What we have acquired in a life time of study and practice is valuable, provided we have obtained and know how to obtain substantially correct results. If we are safe as engineers in our calculations and practice, if we are of an advantage to the owner, it is right for the owner or his agent to pay us for the service. There is one thing that I have not heard you touch upon which might be spoken of briefly. There seems to be a little fear among members of our profession about asking something for their services and they are very delicate as to the way they put it and all that, and they are afraid if they ask five or six dollars for a ten dollar service that the owner will want to cut them down to two or three, or something of that sort. In that case the fault is not with the owner at all, it is with ourselves. If you have acquired in-

formation and can impart it in such a way as to benefit some other person you are entitled to compensation. But if you set a minimum value on your services, you cannot blame the owner for wanting to cut it down still more. If you hesitate to charge for it at all, you cannot blame the owner if he does not offer you anything for it. The remedy is largely with each individual, and yet collectively we can help each other. There is no doubt about that. There is no doubt that a proper resolution upon this subject and a free discussion and the coming together and education of ourselves in this way are beneficial. We cannot educate the whole world by meeting here; we cannot educate the whole world by a little argument of half an hour with some one owner. But if each of us takes a stand as to what his services are worth, and holds to it, we shall no doubt, as a rule, receive a fair compensation, provided we study and bring out a suitable plan for the building before us. We need, of course, in presenting a plan to put into that plan the result of years of experience of ourselves and of other persons, and to give the owner such a plan as shall probably be satisfactory to him, a plan which he should in all reason be satisfied with and which will be of advantage to him. Now, if we go to the architect or owner and present a carelessly drawn specification, an incomplete plan, and then feel a little offended because the owner will not pay a high fee for it, we cannot blame him; the blame still rests with ourselves. In the first place render him a good and valuable service; then you are in a position to demand a fair compensation for that service. In order to do that, I do not doubt but that each and all of us need to perfect ourselves more in the art. While we have given our lives to the study of this business, yet the field before us is very wide, and we need constant application and constant study to keep up with the times and the demands as they come and to be in position, when we are called on to make these plans and specifications, to do them in such a manner that they shall be in all reason above criticism. That is the great point, I think. It is the intrinsic thought you put in them, and when we know we have put the value in them, then we can demand compensation for the services rendered. I have had but very few cases where a proper fee has not been willingly paid for such services when it was asked. There have been cases where there has been some little argument over it, and cases where the price was disputed somewhat, but taking my practice as a rule I feel very well satisfied in that respect that the parties to whom I have rendered services have been willing to pay the fee that I thought was right for the services rendered. As I said, I think it lies with ourselves to render

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a good service and to value it ourselves and then let the party who employs us value it likewise, and it is a matter, of course, as I say, to be taken up collectively, but also largely individually, and the evil I believe is susceptible of being cured.

Mr. William A. Russell :—For several years I have been doing work for different large boiler concerns and it seemed that the only trouble that they had, and the only thing that seemed to weigh on their minds, was that they could not turn out enough plans to sell their boilers. I have been called to account because I could not turn out one hundred plans and specifications in a month which they were giving away free. In five years I got but one fee for making plans, and that was $50 for a small house. This thing is carried on every day and I do not know how we can reach these men and avoid that. Of course my living is greatly dependent upon my ability as a draftsman. I have also sought such positions and filled them to the best of my ability, but I do not know of but this one instance in probably a good many thousand plans for which they have ever received any return or ever tried to get any return. I would like to know how we are going to avoid that, how we are going to meet these men and have them get paid for their work. I would like that to be brought up. It is all right in large power plants, but when we come down to house heating that is where the stumbling block is going to be.

Major Light :—The relation of the carpenter and joiner to the architect is a very intimate one in a general way, and they perhaps sustain the same relation to one another that the manufacturer of heating apparatus and of boilers should sustain to the heating and ventilating engineer. I have known some carpenters and joiners that were very free to put out a plan and detail for a projected building, but they found out after a while that that would not do. The architect, just as soon as he got a chance, would hit that fellow and he would not get the contract under him. Contractors for buildings, although they know very well about their buildings, do not find it a matter of policy to prepare plans and details and attempt to buck against skilled architects. The parallel that I would draw is this : there are men of known skill and attainments as heating and ventilating engineers, and I was wishing, while this discussion was going on, that my old friend Mr. Charles Newton of Baltimore was here, who is perhaps one of the most able men in this line in the country. I would have liked to hear his ideas about some of these things. He is certainly a very skilled man and a man of very great and extended experience, more so probably than any one man in the country. But suppose, drawing that parallel, that we have

our heating and ventilating engineers of known repute, skilled practical men, men that by common consent are credited with the attainment that I have described, and they prepare, and we demand that such men shall prepare the plans and specifications for heating and ventilating. Now, the average contractor will get just as much money, and I think a little more, if it is worked up on that line than he would in attempting to get it in the way of the skilled heating and ventilating engineer. I have always noticed this in about 25 years of experience that I have had that it is the most unsophisticated, superficial engineer that becomes the most active just about as something is to be done in that line, and he is the man many times that apparently knows all about it, while those who are really skilled and practical, and to whom such matters should be referred, know nothing about it. Now if a skilled engineer was employed to prepare plans and details and the contractors insisted that some such man should make the plans and specification, then the complete plan which all the details involved would be presented for competition, and the gentlemen bidding on those plans and specifications would bid for just as much money or more perhaps than they do now in the average of cases, taking the country at large, and the completeness of the plans would lead to a higher line of bidding by the competitors. But because the specifications and details are many times incomplete the competitors do not realize fully what is involved and as a consequence their bids are altogether too low, making it unpleasant for the man who is a little more advanced as a contractor and yet perhaps not the skilled engineer I speak of. I know of a plan and specification made this season by an architect in Detroit for four state buildings, and in common with the other contracts that are being let bids were asked and quite a number of bids were put in, and some men who knew very well about such matters said, "That plan is thoroughly impracticable; it cannot be done," and they hesitated about bidding, and yet quite a number of bids were put in and the contract was awarded to the fourth highest bidder. Afterwards the plans and specifications came into my hands for execution. I had paid no attention to it up to that time, but my son had. I said, "That thing will never be a success. The building cannot be heated by those plans; they never will succeed in getting the steam through and getting the condensation back.'" I said, "You ought to have looked at this last spring. What I should do would be to go to the state superintendent in charge of the building and state the fact positively, and if he wants any further demonstration propose that it be referred to some skilled man in he business." That was the final conclusion. I went to the su-

perintendent on Wednesday. I stated fully what was involved and that they could never make it run. The boiler house, by the way, was the highest grade of any of the buildings, which you know is the reverse of the common practice. Saturday of the same week they called a meeting of the state commission in Detroit, and I went before them and represented the matter and it was adjusted, and yet there were some questions left open. The chairman of the commission, claiming to be practical himself, claimed some conditions that were utterly impracticable. It was deferred for a month. I sad to him, "I have presented to you my ideas, the best that I have. It may be that I am mistaken, yet I am quite positive that I am not. I will tell you what I will do. These questions that are in dispute I will agree to refer to the American Society of Heating and Ventilating Engineers and by your consent we will ask the president of that association to appoint a skilled engineer to determine these questions." Just as soon as I put it in that shape, that gentleman was through and there was no trouble in arranging all the details. I claim that the contracting trade in the steam heating and ventilating business will make just as much more by the plans and details being made perfect in the commencement and being prepared by known skilled practical engineers and then bidding on them for all that is in them.

Mr. Harding :—There is one element that has not been alluded to and that is the effect of legislation upon the preparation of a certain class of plans. I might state an experience that I recently had myself in connection with the preparation of plans for heating and ventilating a building in Massachusetts where, as most of you know, there is a law requiring a definite result in point of air purity or volume of air. I was asked by a local man, who had had no experience in heating and ventilating particularly, to prepare plans and specifications for the heating of a building. I did so. The building committee had six bids and I had therefore five competitors. If I had charged my time up at what it was worth, it would be about what the average was for the six competitors. The cost of each set of plans and specifications would have amounted to $60. There were six. That made $360. The amount of money appropriated to pay for the heating and ventilating of the building was $1,000. Before a bid was accepted $360 worth of plans and specifications were made of which only $60 worth were made available to the board. When the plans and specifications were submitted to the committee they appointed one of their members a committee to go to Boston with the six sets of plans. He went to the State House and saw the Massachusetts District Police

Inspector for that district. I will say here that the inspector is a man at whom a great deal of mud is thrown. He has probably had a larger experience in the inspection of heating plants than any man in the business of heating and ventilating in the state. The inspector picked out a set of plans which he conceived to be the best. He said to the committeeman "I conceive that to be the best set of plans for your interest." The committeeman went back and said to his confreres "This is the set of plans the inspector approves." They voted to award the contract to that bidder. There was $300 gone to waste, and I think this points out a field of work for the consulting heating and ventilating engineer.

Prof. Carpenter :—The paper by Mr. Jellett is an excellent one and I hope may be of use in correcting the manifold evils pointed out. The system of evils rests, no doubt, on the desire to sell certain specialties which can be introduced into use if an opportunity is given for drawing up specifications. The engineer expects pay for his services in the shape of commission on the goods used, and it seems quite certain that his pay will be less when received in that shape than in a more direct form. Indeed, I am satisfied that this system is much more costly to the owner than that of paying directly for the plans and specifications and having them drawn so that free competition can be obtained from all manufacturers and contractors. So long as the designing engineer is connected with the sale of some specialty so long will the abuse pointed out in the paper continue. It would seem that in the case of the heating and ventilating apparatus the contractor should have the same responsibility as in other classes of work. He should be responsible for material and workmanship, but not for any feature of the design. In my own practice I have never held the contractor responsible for anything but actual construction. I have never sought to evade responsibility for any error arising from improper size of distribution pipes or radiators, and it seems to me that the whole difficulty relating to tests in zero weather will be at once solved if the engineer takes all responsibility of design, including distribution of heat, from the province of the contractor.

XUM

X.

HEATING AND DRYING BY THE USE OF EXHAUST STEAM AND LIVE STEAM REDUCED TO LOW PRESSURE, EITHER SEPARATELY OR IN COMBINATION.

By Alfred A. Hunting.

(Member of the Society.)

Heating and drying by the use of steam in a primitive way dates back to the time of its being first successfully used for power. Boulton showed by actual use that exhaust steam could be carried long distances in pipes and that a high temperature could be developed in drying rooms by its use.

Steam for heating has been a favorite study with many engineers, and such use has been highly developed in certain lines, especially in high pressure work, while less attention has been paid to the utilization of exhaust steam and heating at low pressure on a large scale. Heating by exhaust steam has been a bone of contention, many arguing that it was absolute waste to attempt it, that it was much more economical to allow the exhaust to go to waste, and that it was better to have a free exhaust and to do the heating by live steam.

The plan of piping to use exhaust steam for heating and drying, as generally designed, causes a back pressure at the engine.

This is especially true of the early work in this direction, where 10 to 15 pounds back pressure was used to force the steam through a system. Even to-day it is not unusual to find similar conditions. Lately, plants have been put up to work with only 2 or 3 pounds of back pressure.

It is wasteful to heat with exhaust or live steam above atmospheric pressure under ordinary circumstances, even where the plants are of the largest description. It needs no argument to prove that back pressure at an engine is a loss in the ratio of back pressure to mean effective pressure, especially when better results can be obtained by the use of exhaust steam, all back pressure being removed from the engine, and the engine actually working under a vacuum, which can be shown by indicator cards

and by gauges. Steam heating plants vary in conditions, no two plants being just the same. There is no cast-iron rule to be laid down by which they should be designed or by which they should be operated. Where engines and pumps are used, the steam which passes through them gives up a certain amount of heat units in power, still retaining, however, more of the said units than is generally sufficient for heating, drying, or for kindred purposes, even after passing through a feed water heater and heating the water to a point near boiling. It has been satisfactorily shown in practice that steam at a pressure at or below the atmosphere heats the system more uniformly; that products of manufacturing processes are increased, and at the same time that a large saving in fuel and other economies are effected.

Given a building of certain dimensions which is to be used for a purpose requiring steam for power, heat, and other purposes wherein the cost of steam for power is the same as the cost of steam for heating and other purposes, the two costing say $10 per day. Now, use the exhaust steam for heating and other purposes, and your bill for steam is cut in two, making it $5 per day.

The saving will be greater or smaller according to the size of the plant and the amount of exhaust steam utilized. In cases where the uses to which exhaust steam can be applied are greater than the production, then live steam at a pressure corresponding to the exhaust steam, i.e., atmospheric pressure, can be fed into the system to make up the deficiency, the two working in perfect combination and causing no back pressure.

In many cases where exhaust and live steam are fed into a heating system usually run under pressure, the exhaust steam goes to waste, the live steam doing heating, by which practice the cost of heating is doubled instead of being lessened, as was the intention. There are many cases where small engines and pumps exhaust into one main exhaust pipe, the terminal pressure of no two of them being alike. Under these conditions (where a system is properly designed), the steam may be perfectly utilized for heating or drying without causing a back pressure on any one of the combinations of exhausts.

In a well devised system the water of condensation should all be returned to the boiler. There will, of course, be a small loss, but by the use of care the water bill may be reduced to a small item. In plants where the engines and pumps are stopped at night, the heating can be done by steam at reduced pressure from the boiler direct. This keeps the building perfectly heated, both by day and night, which is a more economical practice than to

allow it to cool off during the night to be heated again in the morning.

In the ordinary steam system run at moderate pressure, bubbles of air form on the interior of the pipes, radiators, or dryers. After a time, if there are impurities in the water, the pipes and radiators are covered with scale, which covers the bubbles as well as the rest of the interior of the heating or drying surface until the whole interior is coated with a first-class insulating material, the heating surface losing in efficiency as such coating increases. Such an interior coating also retards the flow of the condensed water. Water in pipes acts as a condenser and abstracts heat that should be given out through the heating surface. When it is attempted to remove air and water in the ordinary way (that is, by pressure) a large per cent of the heating surface remains inoperative because such air and water are not properly or efficiently removed. Results count. The best system gives the best results. In a large office building in Boston, where it was supposed that everything had been done in a manner conducive to the best economy in coal consumption and the general operation of the whole heating plant, a saving was made over the previous year (in four months' time) of over $1,000. How was this done? Simply by the removal of air from the heating system, relieving the engines and pumps from all back pressure, and by discontinuing the use of live steam. The manner of piping and method of working in this case gives the results. It is equally effective whether exhaust or live steam at or below the atmosphere is used, or where steam at pressure is found to be necessary.

DISCUSSION.

Mr. Onderdonk :—I do not think that the paper which has been submitted will admit of any discussion. The gentleman has stated a fact, and that is a stubborn thing. We all, I think, have learned by experience that it is penny wise and pound foolish to heat a building by live steam and throw away the exhaust. Of course I might relate numbers of experiences that I have had in that line. We know that in modern plants the idea is to get the minimum back pressure, and as Mr. Jellett stated yesterday, there is a building in the city of Philadelphia which is heated through almost the entire cold season with a vacuum and we think—well, I won't say we, but I think that a great deal can be accomplished by making the pipes large and the flow easy, and that a building wherein much power is used can be heated, you might say for nothing, if there is enough exhaust steam to do it.

I have a building now in mind in Philadelphia which is rather small in proportion to the amount of power that is used for operating its machinery, and the owner of the building has not been compelled so far to utilize more than about half his exhaust steam, and he has enough to supply two or three neighbors if they would rent it of him, and it is evident that that is the most economical plan, and it would be foolish for him to throw away that exhaust steam and take live steam to heat his building. I have an intimate friend who had two 40 horse-power boilers. He was heating his building and running his machinery, and by my advice he changed the system of heating to one of exhaust, dispensing entirely with one boiler, and he got all the power he needed with one boiler while he had two before.

Mr. Barron:—This paper is in favor of something that I am exceedingly sceptical about, although I am not so sceptical but that I am quite willing to be convinced of its ability to do all that is claimed for it; that is, removing air from radiators and getting much more perfect heating by a more perfect removal of air. I have always been sceptical of all systems of removing air from radiators since a number of years ago, when I took an agency for a vacuum system, although that is not an exact description of it. I executed one contract under the supervision of the inventor, and I never executed any more, not because it was not perfectly satisfactory, for it was, but because there was nothing to it any more than a direct return of steam. It was entirely satisfactory, but there is really nothing special to it in my opinion. It was not a system that could have been covered by a patent, or had any special appliances in connection with it. It was simply an ordinary direct pumping system. I have had some other experiences in exhaust heating a good deal after the plan laid down by Mr. Bates in his paper read some few years back before the Master Steam Fitters in Boston, that is, utilizing exhaust steam by running it into a tank and distributing it from a tank. Recently I executed a small job on this system at 116th street and 8th avenue. It takes the steam from the elevated railroad pumps and distributes that steam over 600 feet of radiating surface in a number of radiators in a 2-story building without any back pressure on the pipes or pumps whatever. The elevated railroads own the pumps, and they would not allow the owner of this building to use the exhaust steam if it made any back pressure. We made provision to put in a boiler in case it was necessary. We connected the exhaust steam to the pumps by a five or six inch pipe, and we distributed that to a 4-inch main running down about 50 feet.

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From that we run a 1½ inch steam riser to the second story and a ¾-inch return riser connected with the return. The return pipe goes into a blow-off tank. When we first started it we blew the air out of the system by means of a back pressure valve, and it has worked since continuously. I do not know whether the engineer, if they do not get heat in the radiators, closes the back pressure occasionally to accommodate the people. The understanding was distinct that the steam was to be taken from an open exhaust pipe. I have inquired if the heating has been satisfactory. The owner and the tenants say it is perfectly satisfactory. It simply is the use of very large piping, that is all, and it seems to me that we can get just as good results that way. I think it a matter of expediency whether you use a small pipe and a device for exhausting the radiators and the system, or you use very large mains and blow out by pressure. That is my point of view, and I think it is the disposition of a great many steam fitters to look at it that way. We are apt to be afraid of new devices, not because they are not good theoretically. If the intelligence of the engineers, or those who have them in charge, was of a little higher standard, or if they were paid better, if the positions were more responsible, and there were men to look after these devices, I know they would be good. But under a great many practical working conditions I am very much afraid of them.

Mr. Harding :—Do I understand Mr. Barron to say that the use of exhaust steam, without any means of removing the air by any system of piping, can be accomplished as thoroughly as by some means of removing the air?

Mr. Barron :—That is practically what I said.

Mr. Harding :—I wish to take exception to that position, and I would point out a few things which probably some of you know better than I do. The circulation of exhaust steam, although there may be an automatic air valve on the radiators, is accomplished by back pressure on the engine. It cannot be accomplished without a modicum of pressure, however little, except some process for removing the air from the system be applied. The presence of air in the circulation of any steam heating system is, as you all know, one of the greatest enemies to success. By the perfect removal of air, if it were possible to accomplish it, it can be proved that the radiating surface at the pressure of the atmosphere or less can be made more effective in raising the temperature of the room than heating under a pressure of from 5 to 10 pounds. The air which is impelled through the system or admitted to be forced out by pressure is not thoroughly removed from the system,

and a very large portion of the radiating surface is not effective for that reason. As a method of proving that, I might mention some tests which have been made which might be of interest. Any of you gentlemen know that if the air valve on a radiator is opened and the air is all allowed to escape, presumably all allowed to escape, and then all the valves are closed, the steam will condense and a partial vacuum will be formed. The question arises what amount of vacuum will thus be occasioned by the condensation of the steam. By test on radiators of average heights and conditions it has been found that the vacuum formed by the condensation of the steam contained in the radiator and closely confined by the closing of the valves will produce a vacuum equivalent to from 15 to 17 inches of mercury, and that in no case has it been found to exceed 17 inches of mercury vacuum; this when the radiator has been filled with steam by opening the air valve or by taking the pet cock out of the last section of the radiator and allowing the steam to blow through it and then closing the air valves. It has been found by the process of removing air through the valve, without any pressure and the steam allowed to flow into the radiator at a temperature of 212 degrees or at less, and then closing the valve, that the steam would condense and cause a vacuum of 29 inches and a fraction over. The process of blowing the steam entirely through by pressure with the pet cock out is as complete a means of removing air when pressure is used as I think can be found. Now where does the difference come in? Where is the difference between 17 inches of mercury vacuum and 29 inches of mercury vacuum (in the latter case it being by the removal of air)? Does it show that the air cannot be removed from certain pockets and other places in the radiator and circulating coils by pushing from behind or by driving through in the form of pressure? I prefer not to say anything more without further discussion gives evidence of interest in the subject.

Mr. Barron :—You get a radiator hot, you do not expel all the air, but I think steam in condensing forms bubbles of moisture on the sides of the radiator, for instance, and all those bubbles are more or less full of air, and it is only a question of time when the condensation will absorb nearly all the air in the radiator, so you are nearly getting perfect work in the radiator. Of course I know that if the radiator is air-bound and there is no heat in there at all, you cannot do that, but assuming that you expel the air from the radiator as ordinarily done, then the process that goes on is that in the center of each bubble of moisture on the walls of the radiator is air. In other words all water is mixed with air more or less. I

believe a particle of dust forms the center of our raindrops. On that principle I think air forms the center for the drops of moisture inside the radiator. That is my idea of it, and no process of removing air can perfect that. You can only take the air that has separated itself, and it seems to me that is all you can do. Whether you pull that air out or push it out it does not seem to me to make any difference. You take out all the air you can. Any process or any device for taking out more air I incline to be a little skeptical about. Those who have had practical success with this system believe they do get all the air out of the radiator. I have heard gentlemen state that radiating surface nearly doubled itself by a thorough exhausting of the air from the interior of the radiator or coil by an exhaust device. Of course if that is so that is one of the most extraordinary facts that we have in the line of heating and we should know it, and I would like to hear from some one on the subject. I am sorry Mr. Hunting is not here, because he has made numbers of tests, I believe, and has much data.

Major Light :—I would like to inquire of the gentleman who spoke last if the position taken by the gentleman he refers to was from actual tests?

Mr. Barron :—Yes, sir. This gentleman was engaged in erecting apparatus for a company. He is a man of very high standing. He told me personally of these matters. He got extraordinary results from exhaustion devices.

Mr. Quay :—There is more than one way of removing air from systems. The system I think that has been referred to mainly has been that of removing the air from the radiator. There is another system of maintaining a vacuum on the return, which we have used and have seen in operation. I remember one case particularly where they had a lot of power engines and pumps where they maintained a certain vacuum on the return, and where they used the exhaust steam for heating entirely, where the back pressure valve was entirely open and there was no exhaust going out of the exhaust pipe except when they had more than they needed for the heating. I do not think that you can get those results without a vacuum system, or without some system of removing the air. Perhaps vacuum is not the proper term to use. If you have very long mains, and under certain conditions it is necessary to carry a certain amount of pressure, it was stated yesterday by some one that we got just as good results from atmospheric pressure, and of course we do. But we have found by actual tests that you do not get the same pressure on the extreme end of the main, especially if it is long, that you do at the blower, and in order to have the

pressure that you desire at the extremities you have to carry a certain amount of pressure. I have never seen any case where you could carry a pressure on your system of five pounds, say, and not have a back pressure on the engine unless you have some way of either removing the air, or a vacuum. There is another point that might be considered; in maintaining a vacuum of a certain number of inches you reduce the temperature of the steam below atmospheric pressure. Now the question is whether you need to use more radiation in these cases to make up for that lower temperature, or do we get enough better circulation, as is claimed by the people advocating these systems—do we get enough better circulation so that the same amount of radiation at a lower tempertature—steam at a lower temperature—will give the same results? There is another question with regard to the size of the piping that I think is worthy of consideration, and also the construction of the piping.

Mr. Harding:—There is one point in this connection that I might allude to in the line of what I said with regard to the condensation—a vacuum of 17 inches produced by condensation within a radiator, the air having been removed in the ordinary methods, and a vacuum of 29 inches being produced when the air has been removed by a process invented for that purpose, and I desire to point out the effect of a vacuum within a radiator in circulating the steam, if you choose that term, or what is a better term, the bringing of the steam to that point. The condensation of the steam in the radiator, when the automatic air valve does not open, has the power with the air removing device of 29 inches vacuum, or approximately 14 pounds minus pressure, to draw the steam to its point of use or into the radiator, and by the device by which the air is removed the automatic air valve does not permit the air to return to the radiator upon the condensation of its steam, and this power of condensation, as I would choose to term it, has the effect of drawing the steam to the point of use by the removal of air. The radiating surface is more effective, as every square inch of interior surface of the radiator is in contact with steam without a film of air between, and as was shown, I think conclusively, in the previous argument, the lower the temperature of the radiant body the larger the proportion of its heat imparting quality is by contact of air, and heating by contact is the most efficient and economical method. Therefore, the lower the temperature and the greater amount of surface in use the greater the economy in obtaining the heat required in the room. I believe that is in the line of an answer to Mr. Quay's question.

As to the desirability of working without pressure, as to the size of mains, there is an axiom that there is no friction in a vacuum. Without depending upon that for a reason, I would say that if steam was being discharged at a high velocity and temperature from the engine or from the boiler through the mains, there is a vast amount of friction between the air, the water, and the steam, and if that element of friction is not entirely removed by a process of obtaining the flow of steam to its point of use by vacuum caused by condensation, it is removed to such an extent that very much smaller mains and risers will accomplish even better results than large mains with pressure.

Mr. Barron :—I want to correct something. I stated we were heating without any back pressure whatever. I know if an indicator were applied to this machinery there would be a slight back pressure, and we are depending on that to do our circulation. I want to make that correction. Although we made no tests, judging by the size of the exhaust pipe and its length, there was enough pressure to create a slight tendency for the steam to go the other way, and we simply took advantage of that to get our circulation. The friction was there anyhow. We do not regard that as any particular detriment. But if it was on the engine, and the engine was large, it would be well worth considering.

Mr. Harding :—I have no desire to absorb the attention of the meeting with what little value there is in my remarks, but I will take a few moments in relation to this matter of the value of pressure and the matter of back pressure. I have in my hand an indicator diagram which was taken in my presence from an engine in a building in which there are 20,000 lineal feet of 1-inch pipe in an indirect stack showing less than ¾ of a pound back pressure. I could further demonstrate why this ¾ of a pound back pressure is there. It is in the throttling of the connections between the exhaust pipe and the coil. Before a device was applied to that stack heater for the removal of air the back pressure upon the engines, of which there were two of 125 horse-power each, was from 8 to 9 pounds. Since the application of the air-removing device the coils have shown a greater efficiency in imparting heat units to the air conveyed to the various portions of the building, and there is only ¾ of a pound back pressure on the engines. If any one would like to see the diagram I would be glad to show it.

Mr. Weymouth :—I would like to ask Mr. Harding if there was any alterations made to the pipe work when you attached this system of removing air.

Mr. Harding :—Absolutely none.

XI.

TOPICAL DISCUSSIONS.

First Annual Meeting.

TOPIC NO. 1.

In designing a system of heating and ventilation, shall we heat by radiation and supply only tempered air for ventilation, or shall we heat by the air supplied for ventilation?

The President:—I will ask the gentlemen to confine themselves to the topic and not to branch off into side issues. The subject is open for discussion. Mr. Onderdonk, it is suggested that you open up this subject. If you are willing, we would be glad to hear from you.

Mr. Charles S. Onderdonk:—Mr. President and Gentlemen of the Society, I am ashamed to say that I am totally unfamiliar with the subject, not having seen the paper or the subject of discussion. I have had considerable experience in heating buildings by means of the fan system, which is ventilating with the same air with which we heat the building, and it seems to me that that is the proper way to do it. I have heated buildings where I put in direct radiation for heating the air, and then a moderate amount of tempered air for ventilation. But it seems to me that it makes a double system and a complication of things that is entirely unnecessary. We can control the inlet of the warm air and the temperature of the warm air and keep a constant flow by merely controlling the heat by a thermostat or by valves, and it appears to me, without going into the thing at length, that my preference is to heat the building with the same air with which we ventilate it. I may say more on it when I hear some discussion.

Mr. Stewart A. Jellett:—The question for discussion applies to a particular class of heating, I take it. "In designing a system of heating and ventilation, shall we heat by radiation and supply only tempered air for ventilation?" That practically restricts it to certain classes of building. That combination, "Or shall we heat by the air supplied for ventilation?" implies either an indirect

system of heating, a direct system of heating with independent ventilating flues, or a fan system of heating; one of the three. Direct radiation in an office building, without ventilation, would not come under this heading, and the average dwelling house heating need not be considered, because you would not have power in your ventilating flues unless you heated them from your boiler, which is not the general custom. It strikes me, then, that the system to be considered here is one in a building occupied by a number of people, either a hospital, college, school, or public building of some class. I have designed systems of heating using the three different methods. I have used purely a fan system of heating where all my heat was in one central chamber. I have put the system in, with and without exhaust fans, without extracting the air from the building, depending entirely on the pressure from the blower. I have put in a system of direct radiation into an old building where the windows were loose and the construction bad, controlled these radiators by thermostats, and ventilated the building by an independent system of tempered air from a blower. The full volume of tempered air was being maintained at all times irrespective of the direct radiation. I have three large buildings in mind where I carried out this system.

One building is used irregularly. At times a room that has 100,000 cubic feet of space has 600 men in it for twenty minutes. Then it is out of use till the next day. The object in designing the combination system was to save steam, and we wanted the air fresh at all times, and at the same time enough heat to keep the furniture and decorations in good shape. In this building we put direct radiators under the windows on the outer exposures. The windows were all loose, many of them of stained glass. These direct radiators were controlled by the Johnson system of thermostats. The ventilating flues used were the old flues in the building. There is a fan blowing in tempered air. It is delivered in the room at a temperature of about 70 degrees Fahr. The direct radiation was put on early in the morning before the men assembled, and after the twenty minutes or half-hour session, the man in charge threw the switch and cut off the direct radiation. But the tempered air was maintained at all times. It is a medical college and the odors in some of the lecture rooms are very bad from the fact that dissections take place before the classes. There are four different amphitheaters in the building in which classes meet, and the air is vitiated very rapidly. The arrangement described gives us the maximum

amount of heat and ventilation needed and a uniform and controllable temperature. The system has been one of the most satisfactory I know of.

The President:—Did you state how you warmed the fresh air?

Mr. Jellett:—We warm it by means of coils of pipe. It is an exhaust type of blower, taking air in at one side, and we use only enough heating surface to raise the incoming air to a temperature of 80 degrees; this temperature is regulated by a thermostat in the main air duct, and we are blowing through the old stone flues in the building, which is an old one, erected some twenty years ago.

In another institution, which is an insane hospital, we use indirect radiation supplemented by a blower and tempering coil. There are some seven buildings supplied from a central station. Each main ward has, say, twelve flues. Under half of them we put indirect radiators. The fan discharge is connected to these and we also connect to the other flues directly from the fan without using any indirect radiators. The fan has a tempering coil. In case anything happens to the engine or blower we can at all times maintain the temperature of the rooms by means of the indirect radiation although with reduced volume of air for ventilation. We depend on the employees of the institution to keep the plant in repair, as it is some distance from any city. The air supply was fixed on a volume of 3,600 cubic feet per hour for each patient. As 60 patients are placed in one ward it takes a very large volume of air. The system has worked very satisfactorily. On very cold days only is the indirect radiation used at all. When the outside temperature gets down to about 18 degrees then the supplemental indirect radiators are added. Ordinarily the fan and tempering coil carry the whole system. This combination has this advantage over the ordinary fan system, viz., that we have two means of protection against entire want of heat. If the fan gives out we have the indirect radiators, not sufficient to keep the building at 70, but sufficient to keep the occupants from suffering, or if anything happens to the main steam pipes supplying the indirect, we have the fan, and we can increase the speed. The object of the plan was, of course, to be as far as possible independent of breakdowns, because the institution is crowded. They had no other place to put their patients in case anything happened to any one of the seven buildings, four being used for dormitories and the others for administration, power house, servants' quarters, and purposes of that

kind. There is no trouble to maintain the temperature or the volume of air.

I have placed fan systems, pure and simple, in college buildings. I have one in mind where the building is of an L shape, 400 feet in length, the fan being in one end. The only effect noticed here is the loss of temperature between the fan itself and the ends of the line, which would not occur if we had the indirect radiators to help us out. I found a loss of 30 degrees in the transmission through this 400 feet. The basement is not used for anything but heating apparatus. To reduce this loss of 30 degrees under heavy wind pressures the main pipes and the end flues were increased in size, but at the same time it was most difficult to maintain the temperature in those end rooms. The other system of using auxiliary coils or radiators gives you more chance of control, you can regulate better, and you can apply a thermostat system. A thermostat system applied to a fan system, pure and simple, is very difficult to regulate, because the flues are at varying distances from the source of supply, and the air loses in temperature in transmission from the blower. If you put your thermostat at your main heater it is likely to shut off the steam when the end exposures still require the heat. My experience has been that the combination system is the better one.

Mr. Onderdonk :—If the cost of installing the heating plant is not to be considered, there may be some direct advantages to be derived from the use of the double system of indirect radiation and the fan system. But we all know that very few have carte blanche to put in what their ideas dictate. I have in my experience put in a number of these systems, and I know that they have greatly increased the cost, and the buildings could have been heated just as well at least 40 per cent less than they were with the double system. I had an experience in the same college building that I suppose Mr. Jellet referred to, in another department where, by specification of the architect, I put in a double system, a system of direct radiation and a fan system ; the fan system was to be run in moderate weather, and in extremely cold weather the direct radiation would be applied. Although this was in a chemical laboratory where we would suppose the people would be thorough and would be under the charge of a competent engineer, the result so far, this winter, has been that they have kept the direct radiation on all the time, and when the rooms got too warm they have slowed down the fan. The result is that when the room is warm the ventilation stops and

when the room is cold the ventilation is excessive. Now, Mr. Jellet states that in very long runs of pipes there is a liability of a loss of temperature. I made a test within a few days of a building 130 feet high and I found a loss from 141 to 121 degrees in the eighth story. The building was 40 or 50 feet square, but very high, and the loss was in the vertical flues, and the first six floors were more easily heated than the top floors. This is something that it is hard to overcome. But there are two ways to overcome the loss in a horizontal pipe. If you have a building 400 feet long, and a coil, and a fan, of course when the air reaches the 400th foot it will be cooler than when it left the heater. But if that is the case, a reheating coil could be put on the end of the line, which would be much less expensive than piping up the whole building for a system of direct radiation. Another thing that could be done would be to use a two-pipe system, when the thermostat wants to be applied. I recognize that it would be difficult to control the temperature of buildings heated by one pipe from the fan system, but if you have a two-pipe system you can then throw tempered air or warm air into that room as you please, so it does seem to me that the same result can be accomplished with a great deal less expenditure of money by putting in a simple system.

Major H. E. Light :—I would like to ask the last gentleman who spoke of the difficulty of warming the fourth, fifth, and sixth stories owing to their increased height, if there would be any difficulty in warming them if the flues were properly proportioned.

Mr. Onderdonk :—The only difficulty would be this : You would have to put an excess of air and an excess of ventilation in those rooms to warm them from the same starting point and apparatus. If you could heat a room with a change of air every twenty minutes with a temperature of 140 degrees, and if it lost 20 degrees in passing to the top floor, you would have to change the air probably every fifteen minutes to heat the rooms, which would make an excessive ventilation, and the heat radiating from the ducts would be lost to the rooms below, while in the lower rooms you want so much air per capita on account of the number of occupants. The top floor of this building was one on which fine paper was stored and it was necessary to maintain a certain degree of heat so that the paper would not become impaired. There were only three or four people in that stock room, but on the floor below there were about 40 people. In order to heat the stock room the same as the rooms below I had to do it

once in twelve minutes, while once in twenty minutes suffices for the first story.

Mr. Jellett:—The point raised by Mr. Onderdonk regarding the regulating of heat and reducing the speed of the fan is something that is capable of being controlled. In the particular building that I referred to the engines on the fans are run at a certain fixed speed. The engine room is locked. The occupants of the building have no access to it whatever. The engine room is connected by a tunnel to the central power house. At certain hours of the day the blower runs at certain speeds. The regulation of the heat of the rooms is entirely under the control of the thermostat which regulates the direct radiators. The engines are started every morning at eight o'clock. They are shut off at four in the afternoon, and that run is maintained at all times for the maximum amount of ventilation. The direct radiators, however, are on and off according to the temperature at which the thermostats are set in the room. In certain operating rooms the temperature is set at 75 degrees. We have one or two in which it is set at 80 degrees. In the lecture rooms—the pits as they call them—there are some 500 men crowded into a comparatively small space. The thermostat is set at 61 degrees and the body heat of the men assembled brings it up to 70 degrees. But the volume of air delivered into the room is figured on the number of occupants, and if we get it down to the basis of changes per hour the lecture rooms are changed about once every three minutes. The number of men crowded into a comparatively small air space, the use of chemicals during operations and dissections, affects the air very much. It would not do to put it under the control of any of the employees or any of the occupants of the rooms. If Mr. Onderdonk had some direct radiation in those upper floors he would not have to increase his flues. He could maintain the temperature at one regular thing and not overheat the lower stories.

Mr. Onderdonk:—It is a very peculiar thing that the very same engineer who locks the door to his engine room is the same engineer that I have in my building. There must be some subterranean passage. All I know is that every time I go out there, and the weather is mild, I find the engine running at about 60 revolutions when its normal speed is 180, and I have had various complaints of the lack of ventilation, and I have always attributed it to this same thing.

In regard to the eighth story of a building of which I spoke, all will grant that it is a most admirable feature in a building, es-

pecially a paper house in which fine printing is done, and fine books are printed and published, that there should be no steam pipes whatever in the building above the basement. This building I speak of is from 50 to 55 feet square and eight stories high, and there is not a steam pipe in it above the basement. It is all heated, and comfortably heated. The only complaint is my own complaint; we met this difficulty—the registers were all at the ceilings. Very much against my wishes, at almost the command of the owner, I put cords and tassels on to open and shut the registers. I told him that the trouble would be that when they got too warm they would shut them off and go away and forget them and in the morning they would complain of the lack of heat. I went there myself several mornings very early and found some of the rooms cold and in some cases all or three-quarters of the registers shut off. Then we took the cords and tassels off. The result was that the first stories became overheated and they had no way to shut them off and the story above was comfortable. I think there was a difference of only five or six degrees. I am not thoroughly acquainted with the technicalities of the paper business, but it seems that if they have a very fine glossy paper, unless it has a constant heat of 70 or 75 degrees it wrinkles. I rather took the props from under them when I asked them "Did you have this trouble in the building you were in before?"

"Oh, no," was the answer.

"What kind of system did you have there?"

"Well, we had a system of indirect radiation."

"Did you have the fireman all day Sunday firing the boiler?"

"No."

"Did you have your heating plant on?"

"Well, we put it on, but in the morning our steam had gone."

"How did it do for the next twenty-four hours?"

"There was no heat."

"Did the paper wrinkle?"

"No."

But the fact remained the same that the temperature was different between the lower floors and the upper floors.

XI—TOPIC NO. 2.

In the plenum system of heating and ventilation, which is the better for the air ducts, "off and on" hot and tempered air dampers or "mixer" dampers?

Major Light: I presume my experience in that line is not as

extended as that of some of the gentlemen present, but as no one else rises I would say that I set one of the works last described this last fall and I found it a very great success, and as between that and the other method that is stated, I have a decided preference for the first.

Mr. Harding :—Mr. Chairman, I would like to ask the gentleman who is an advocate of letting in successively warm and cold air—not tempered air—how he is going to provide against the settling of cold air directly on the heads of the occupants of the room, if it enters below the temperature of the room.

Major Light :—It was in a very large school building that this plant was set. I think there were twenty apartments, and we did not find that condition to prevail. I had anticipated that it would prevail, and yet it did not. It may be proper to state that the ceiling of these rooms was twelve feet in the clear, and the heat came in about eight feet up. Heated air, as you know, rises and distributes along the ceiling. There were electrical temperature regulators, and in the operation of them there was a variation practically of only two degrees either way. We did not find that condition to prevail, and on very critical tests that continued for nearly a week, made by the Sturtevant Company, of Boston, the result was considered decidedly superior to what had been their usual practice.

Mr. Onderdonk :—In regard to this matter, my experience is different from that of our friend Major Light. They say, "As you make your bed so shall you lie in it." I remember once I heated an auditorium building. The flues were laid out along each wall the same height from the floor, we will say about nine feet. The architect did not state that the floor was to be slanting. The result was that the registers in the back of the room were about on a level with a person's head. We had a plenum system controlled by a thermostat. When it got too hot it would flap over and let the cold air in, and when it got too cold it would flap back again. I was sitting there when it was flapping. It was at the dedication, and I happened to have one of those registers about on a level with my head. I had a better growth of hair then than I have now, but after about fifteen minutes I had to vacate in favor of the radiator, because the day happened to be about 40 degrees and the temperature of the room was about 70, and the result was that we were blowing cold in almost the entire time of the session. If we had been blowing in air at a temperature of 70 degrees or even a less number of degrees I do not think it would have been unpleasant.

Major Light :—I think that in the case the gentleman cites he

was under an undue exposure. I have no doubt that under just such conditions as he describes the result would be as he says. But in this building the seats were not elevated. The floor was of a uniform level.

Mr. Harding :—I invited two of the inspectors of the Massachusetts District Police to be present here, and upon some of these questions they could give us a good deal of information derived from their practice. In the inspection of 700 school houses throughout Massachusetts, where about thirty questions have to be answered with regard to each plant, a man must get some experience that is valuable. One result has been this : they advocate a mixing valve so placed in the vertical flue that if the warm and cold air going up eight or ten feet do not thoroughly mix together, the cold air will pass up at the back of the flue and go out of the registers in the wall on top of the current of hot air, and it cannot drop through that current of hot air. But if the cold air, even with a mixing damper, is carried up on the side of the flue adjacent to the room it largely follows that side of the flue without mixing, and will descend when it enters the room. Cold air unmixed with warm air will descend in a greater degree.

Mr. Onderdonk :—I have another illustration, gentlemen. My house is heated by indirect hot water. It is ventilated excessively. I bring the heat in at or near the ceiling, about as near as I can get it. I have the flues very large. My heating system is controlled by the Johnson electric regulating system. We have pretty high winds where I live, and in my sitting room, more for style and convenience than utility, I generally burn a log fire, and the result is sometimes that the room gets quite warm and the thermostat will shut off the entire circulation from the nest of regulators. I have felt a draft of cold air on my head so that I have had to move out of the radius of the register, because I have no way of mixing it ; it is either cold or hot. As soon as the pneumatic valve shuts off and as the water cools sufficiently, the air becomes quite cold. Between the time of stopping and starting there is a period of several minutes when the air comes in very cold. So I am still more in favor of mixing.

Major Light :—Just an explanation, if you please. I did not state that we temper all the air before it passes through. We have what we call tempering coils that we set in connection with that and raise the temperature very much, though nowhere near to what the temperature is going to the hot air coils.

Mr. Blackmore :—Our friend from Michigan, I believe, has a mixer after all. I have had a little experience with mixing dampers,

and I am decidedly in favor of them. There is, as Mr. Harding says, a way in which those dampers can work so as to give better results than you can get in other ways. But I think every one who has investigated the subject will admit that it is better for the air to enter the room at the temperature you want the room to be than to bring in a cold blast of air to temper the air in the room. A mixing damper, if properly constructed, cannot possibly let two columns of air to come up that flue. It is natural for cold air to come down. I think if you have two columns that the cold will not go up. The mixing damper in the bottom of the flue is, according to my experience, the most serviceable. So I am decidedly in favor of the mixing damper.

XI—TOPIC NO 3.

The average amount of water condensed per 100 square feet of heating surface per hour in the different manners in which heating coils and radiators are erected.

Mr. Barron :—I wonder if the gentleman is present who suggested that question. I would like to know if it was a hot blast coil he had reference to, or ordinary radiators, or ordinary coils, or if it includes all of them, and why 100 feet—why not one foot as the unit? I think the old rule was $\frac{5}{8}$ or $\frac{3}{4}$ of a pound per square foot per hour, if my recollection serves me right. But that varies with all the different tests. It varies with so many conditions that the question should be made definite.

XI—TOPIC NO. 4.

The necessary size of risers for a given amount of heating surface, for the different sizes of pipes and coils, and for different classes and sizes of radiators.

Mr. Barron :—I do not know who suggested that topic, but I think it is a very interesting one. I think the practice in this country varies very much in respect to risers, and it would not be any harm to get the opinion of a few of those here in regard to their own practice. It is very general, I think, where there is a $1\frac{1}{2}$-inch riser to run a $1\frac{1}{4}$-inch return pipe. There is no question but that a $\frac{3}{4}$-inch return pipe will do the same work. I think that must have been the motive of the person suggesting that topic. There is quite a variation of practice. Men must have some reason for reducing the pipe. Instead of making the return pipe half the diameter of the return riser, why do they make it just one size less?

To my mind there cannot be a better proportion than half-size. But nearly everybody in New York reduces by one size. In all the specifications that are made I think they are specified in that way. I never could see the reason for it.

Mr. Jellett :—This question should be narrowed down to "the necessary size of risers for a given amount of heating surface in radiators." The rest does not belong to the subject at all, I take it. I am not familiar with the practice in New York. We in Philadelphia, who are notoriously slow, do not figure things on any such rule as given by the last speaker. We proportion steam supply and return pipes to the square feet of heating surface served, in sectional area of the supply pipe, and we proportion returns in the same way. We have a different rule for proportioning direct radiating surface and indirect radiating surface. We use a fraction of a thousandth of a square inch of area to each square foot of radiating surface supplied. We take so many thousandths of an inch of area in the main, a still greater proportion of area in the horizontal branch lines, and a larger proportion in the immediate radiator connections. It is all worked down to the amount of condensation coming back from so many square feet of heating surface doing its maximum duty. A rule of that kind can be established that is always a safe rule to go on and has no reference to any particular class, but is a definite thing that applies to all classes of buildings and to all classes of radiation, either direct or indirect, and the proportion of area of inches in each case can be defined so that it is always safe to go on and is not excessive. Such a rule is, I think, a good rule, because you do not assume anything. You lay out your plans and your amount of heating surface to be connected with each different riser and each different return, and you know that this proportion of pipe will supply those radiators with the maximum amount of steam required, and the return pipe will return your water.

Mr. Harding :—In my experience in proportioning mains and the size of radiators I have been largely guided by one authority with whom we are all familiar, and that is Mr. Baldwin. Mr. Baldwin is present, and I am very certain that every one here would be glad to have an expression of opinion from him.

The President:—We would certainly be pleased to hear from you, Mr. Baldwin.

Mr. Baldwin :—Mr. President and Gentlemen, I am afraid I am hardly prepared to talk on this subject. I would refer to one point which I think Mr. Barron made with regard to the relative size of the return pipe of the riser. A riser, we understand, is two pipes, one carrying the steam up and the other carrying the water down. Mr.

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Barron had an idea that a ¾-inch pipe would do alongside of 1½-inch pipe. To commence with, a ¾-inch pipe is only one-quarter the area and not half the area. But so far as the water is concerned it will come down in a ¾-inch pipe. But we have to bring more than water down. We have to bring pressure down to meet the water in the pipes, or we cannot keep it up to its level. So that I think the rule of half the diameter would rather be too small for a return pipe; that is assuming that the steam pipe is of ample capacity, for that reason alone, if for no other. I remember having ideas in my early days very much in the same line where I put in very small return pipes, and I found that, although the water would run back in the pipes it did not go back to our station. With regard to the rule for the size of mains, that is, either horizontal or rising mains, I have never changed my opinion from what it was fifteen years ago when I wrote upon the subject. In fact, practice has confirmed it; that is, not to use smaller sizes than I have given, and in some cases to use larger sizes. A certain diameter is necessary—absolutely necessary. That you must provide for. On that you ought to put all you can afford, because it matters not what the size of pipe is; there is a loss by friction and condensation, and the pressure is growing less as you go out from the boiler. The one-inch pipe to the 100 feet of surface is a rough rule that is nearly correct. That is about all I can say.

Mr. Blackmore :—There are one or two questions which I would like to ask Mr. Jellett. He is not familiar with New York practice. I am not familiar with Philadelphia practice, and I am not one of the New Yorkers either who consider Philadelphia slow in all things. I have met some very bright men in Philadelphia, and I do not think they are few. But Mr. Jellett said that there was a definite proportion of area per foot of radiation. That I think we can all admit is a good rule. I wanted to ask him what proportion he would adopt for direct radiation, or has adopted and found good practice, and also for indirect radiation; and also in using a plenum system what proportion he would use in the coils, feeding those coils that were subject to the blast, whether for different velocities a different proportion also is adopted. I do not know that I care so much for the proportion that he has for direct radiation, but he could simply use the direct radiation as a standard, and say how much more he would allow for indirect, how much more he would allow for coils under the plenum system, say for a velocity of 5 to 15 feet per hour.

Mr. Jellett :—I would say in answer that the rule that I referred to was first suggested by a well-known Philadelphia engineer, Mr.

Charles G. Darrach. It was worked out on a large building under his charge. The ratio for that building is, main riser .006 of a square inch for each square foot of radiator surface ; .009 of a square inch for each square foot supplied from the horizontal attic branches; and .012 of a square inch in the radiator connections on the supply lines. This building has been a very successfully heated building. It has been in use now some seven winters. I have seen on the gauge in that building ½-inch of vacuum. The entire heating system is fed from a 15-inch rising main, passing to the attic and then dropping. I have taken that rule and followed it in a number of cases very satisfactorily. I afterwards studied it out in connection with indirect radiation. I have given .015 of a square inch to the square foot of surface with the ordinary gravity system with cold air supply. I have taken a fan system and given it .020 of a square inch to each square foot of heating surface. But in a fan system I take it that a foot of inch pipe is equal to a foot of heating surface, in condensing effect as compared with direct radiation. With a given number of lineal feet of pipe (say we have a heater of 2,000 feet of inch pipe), the condensation in that is equal to 2,000 square feet of ordinary direct surface ; in other words a foot of inch pipe in condensing power, as compared with the ordinary gravity system of direct, is equal to about a square foot of surface. I then have taken .021 of a square inch of area to feed that, and I have found at all times that I have had ample steam, provided that my returns were properly vented. I have never had any trouble with this proportion. I never, of course, use less than a ¾-inch pipe, because a half-inch pipe is hardly stiff enough to be used in ordinary practice. But when I get above a ¾-inch pipe I follow the rule. In my return pipes, I get back in my main cellar return to about .003 of a square inch. It is the custom in Philadelphia where we feed from the overhead system, not to use any air valves. We come back to our drip tank and use that as the breathing point of the entire system, practically having one air valve for the entire system as against an air valve on every radiator.

Mr. Barron :—In speaking of the relative size of rising mains I had not in mind a gravity job at all. I cannot yet see the reason of having the return pipe just reduced one size. I think that has grown up in the practice of the trade. I think it has grown up because much thought has never been given to the subject. I think myself that one-half the diameter of the return pipes on the two-pipe system for exhaust or reduced pressure, or even for gravity work is correct, and that it is correct to make the return riser and the return main just one-half the diameter of the steam main, pro-

portioning the steam main to the radiating surface. I think that gives a far better proportion, from a theoretical engineering point of view at least, than the proportions usually followed by the steam fitters who do double pipe work generally, and particularly in New York city.

Major Light :—In my earlier days I used to follow one size, but for the last fifteen years, when acting on my own ideas, independent of others' specifications, I have determined the size of the riser and having determined that, for instance, a 1½-inch pipe, I set 1-inch return on the double pipe system. If it is an inch and a quarter riser I set a ¾-inch return, and I never go below ¾-inch for that system. In the plenum system for 1,250 feet of pipe I set 2-inch feeds, and 1¼-inch and 1½-inch returns to the traps.

Mr. Onderdonk:—It is hardly necessary for me to say anything on this question, because I am thoroughly in accord with Mr. Jellett. We were both brought up in the same school. In specifications presented to us by architects we used to say that return pipes should be one size smaller up to 3-inch, and above that two sizes. I don't know that any of us have followed those things exactly. I know that I got into the mire once by reducing my return pipes and getting them down very small, and I found a very great difficulty of stoppage. I found that the slightest bit of sediment getting into the pipe had a tendency to lodge, and I abandoned the use of such pipes. I proportioned my return pipes by the length they had to run. I think it is a good deal a matter of experience, and of the place where they have to go, following, of course, a general rule.

XI—TOPIC NO. 5.

The necessary size of risers for a given amount of heating surface for the different sizes of pipes and coils and for the different classes and sizes of radiators.

No discussion.

XI—TOPIC NO. 6.

The probable future of electrical heating.

Mr. Jellett:—Mr. President, I sent that question in for discussion, because I knew nothing about it and wanted to learn something, and was in hopes that somebody here could enlighten me. There are some men who do know something about it, and if there are any of them here I would be glad to hear from them; I think it is unquestionably one of the coming systems of heating, and as members of The American Society of Heating and Ventilating Engi-

neers we ought to know something about it, or we are not abreast of the times. We have it in Philadelphia, in a number of trolley cars on surburban lines, working very satisfactorily. The cost of it, they all admit, is excessive, but the cost of steam heating was excessive when it was started, and following the usual advance in all methods of engineering, that difficulty will be overcome. The question we are interested in is, when you can bring a wire into a man's house, heat it, light it, and do his cooking, will he have any use for steam ? and if this is a possibility we would like to find out about it.

Secretary Hart :—I intended to prepare something on this subject, but as I have been very busy in getting the papers in shape for the meeting I have not had time to do so. I can say a few words on the subject, but I do not know whether I can stand much cross-questioning upon it.

I believe that under the present method of obtaining electrical energy, the heating engineer of to-day need have no fear of competition from that source. When one considers that it takes one electrical horse-power to supply the current for twelve of the ordinary incandescent lights, the heat from which is equal only to that given off by two gas jets, and that about 99 per cent of this energy is heat, and only 1 per cent light, it is readily seen how much energy is used in obtaining heat. One hears nowadays of electric heating in connection with the trolley system of car propulsion. I predict that such heating will soon be a thing of the past. In heating the cars the heaters are connected in series, six to a car. These heaters require a total of eight amperes, and as the voltage is 500, 4,000 watts or nearly $5\frac{1}{2}$ horse-power of energy is required for heating alone, while 15 horse-power is all that is required to run the car with its regular load. On a line with 100 cars fitted with electrical heaters, it requires the power necessary to run 31 or more cars to heat them. All present methods of heating electrically are by what is known as the resistance system. This resistance consists usually of coils of wire in the heaters, through which the electricity passes and from which the heat is thrown off. In an editorial in Heating and Ventilation, September 15, 1893, criticising the paper of Mr. S. B. Jenkins, read before the Chicago Electric Club, on certain electrical heating experiments, a writer who is well posted on steam and electricity made clear the fact that under the same conditions with steam, assuming an average of seven pounds of water evaporated to one pound of coal, which, as you all know, is low, the consumption of coal was only a little more than 28 per cent of that required to do the same electrically. In this connection I beg to

submit a letter received from Mr. W. S. Hadaway, who is devoting his whole attention to this problem at the present time.

"It is quite impossible to state in a few words the relation of electric heating to present methods, as the collateral advantages in every specific application are determining factors as well as cost of the heat unit per se.

"In room heating on a large scale a close figure for use is that one electrical horse-power will heat (the heat being derived from electrical resistance solely) 7.5 square feet of common radiating surface to 135 degrees F., above the room temperature. You can readily see how far 100,000 horse-power will go when used in this way. It is in combination with present low temperature methods of heat distribution that I look for the greater uses of electricity in heating. Of course, in good practice 50 per cent of the fuel energy is not too much to expect from steam heating on a large scale. We find in practice that few examples of high temperature heating show a fuel economy exceeding five per cent. But by combining the steam for low temperature distribution with electricity for the high temperature distribution we can obtain figures high enough in fuel economy to more than offset the increased fixed charges for the plant, etc., and secure heat energy in a form readily localized, capable of close regulation, and at temperatures from the maximum downwards.

"I think this method can best be illustrated by citing an example of an apartment house. The house is equipped with boiler and electric plant for lighting. The rooms are warmed by steam, and the water is heated by the same means. Electricity is used for lamps, arc or incandescent, ovens, broilers, fat friers, sad-irons, in short for every purpose excepting temperatures at which steam heat is usually applied. This means in practice two profits from the fuel. The electrical load described is obtained from the live steam and all the present live steam uses are replaced by exhaust. In other words the electric plant is merely a high temperature factor, and in its use leaves the energy of steam available for the present uses. It is needless to bring before you the advantages of such a system, as they are too apparent.

"The main feature to be brought out and emphasized is that the installation consists of two factors : first, a high temperature or heat potential system, in which the electric plant is the means of generation and transmission, and a low temperature or heat potential system, in which the electric plant is the means of generation and transmission, and a low temperature or heat potential system in which steam, either live or exhaust, is the means of generation and trans-

mission. And in practice we cannot obtain the high potential system, except from water powers and gas engines, without the low potential system.

"I want to extend the scope of the heating engineer to cover the electric plant. By so doing a greater aggregate economy is secured, and the conditions fulfilled add materially to the comfort and economy of this form of modern life. You can readily see that this is not flying into impossible schemes, but is a conservative view of heating problems.

"I have been greatly interested in the objects of your society, and as I expect to be in New York shortly with the laboratory, I would be glad to attend your meetings. I think your people will find that the careful study of what I have outlined will aid materially in the work of heat distribution, even carrying it to the extent of district heat distribution for all purposes where heat is required, as we do water and gas and other forms of energy, from a central supply."

That is all I have to say on the subject of electric heating. I wish the question of gas heating had come up here. I think that is a direction to which you may look for more competition than electric heating.

Mr. Jellett:—I look on electric heating at the present time as compared with steam heating in this way; you are comparing a system that has been worked out thoroughly with something that is entirely new and undeveloped. I do not take it that electric heating will not be developed. I know that the present system of resistance coils is very expensive in power. I also know from men who have been experimenting on it that they are not at all discouraged. They have reduced the cost considerably. I heard suggested some time ago a new line of thought in connection with electric heating, that is to say a system of radiators with water heated by the electric current; a method of heating water, and allowing it to expand and circulate from a common chamber. Either to do that or take a system of wires through a house and make each radiator its own independent heater. That method is being looked into, I understand, by several electrical engineers. It shows they are getting away from the one line of thought of heating by resistance only.

Secretary Hart:—The method that Mr. Jellett speaks about has often occurred to me. But that has been gone into very thoroughly by the American Electrical Heating Co., of Boston. Mr. O'Neil, an electrical engineer with whom I had some acquaintance, came to Boston with such a scheme as that. After looking into

the thing very thoroughly they came to the conclusion that there was nothing in it. At least they have done nothing about it, on account of the great cost of getting heat electrically. As I remarked, when you consider that 99 per cent of that light there is heat, and only one per cent is light, you can see the great cost of getting electrical energy for heating.

Major Light :—Excuse me. Don't you mean the other way ?

Secretary Hart :—No, I mean just that ; 99 per cent of heat and one per cent of light. The light you get is due to resistance. I figured out some time ago about what 100,000 horse-power would heat. I think these figures here are altogether too high. I think we figured out that we would be able to heat electrically only about 7,400 odd houses by 100,000 horse-power, the houses being of ten rooms each. For my part I cannot see anything in it under any method I have heard of in any way, and I would say in connection with this matter that I have given some attention to the study of electricity.

Major Light:—At Bay City, Michigan, the trolley cars were heated last winter by electricity. During the summer they took out that heating apparatus, and they are heating them by the ordinary method. I made some inquiries about it, but did not get anything satisfactory. They said that heating with the ordinary method the expense was only a fraction of what it was to heat by electricity, and that was the reason the changes were made.

Secretary Hart :—I think I explained the figures in relation to that —about how much horse-power it took to heat them.

Major Light :—I was merely stating the result obtained by that particular company.

Mr. Baldwin :—My attention was called some time since to an installation of an 80 horse-power engine, connected with a dynamo. It was not connected with the house. It was necessary to bring in a resistance coil. We put it in the basement, near the engine, and ran that engine so as to develop nearly fifty horse-power. There were 280 amperes, and a voltage of 110 passed through that resitance coil, which was no bigger than a nail keg. This is no speculation—this part of it—but it would not furnish heat enough to warm a forty square foot radiator, while there was nearly fifty horse-power being used. That is by the resistance coil method. I might say about one horse-power to one square foot of surface

Secretary Hart :—They have tried to secure electrical energy by the thermo pile, and the Pyro battery, and Mr. Cox in New Haven, did secure enough to run an arc light, but the cost was so great that they found there was nothing in it. I believe Mr. Edison and Prof.

Thomson, are working on the subject of trying to get electricity direct from coal. But so far as getting electricity by the round-about methods by which we get it for other purposes, there is nothing in it. I have heard nothing of the experiments of these well known electricians which would lead me to believe that they had as yet in any way found that they could secure this desired result.

Mr. Jellett:—I would only say that there is a trolley line passing near where I live. I use it frequently. The cars are very comfortable. They have six heaters in a car. They run a car every three minutes. The line is some ten miles long. They were running that line of cars with a 500 horse-power engine when they first started the line in summer time. They increased the number of cars in the fall. It is a new line and has been in operation only some five months. They got the power up, as nearly as I could tell, to about 700 horse-power. Since they have heated the cars they are running two 500 horse-power engines all the time. I asked how much power it required to heat the cars and they said they estimated about one-third the energy required to move the car.

Now that would be assuming, if a car takes 15 horse-power, that it would take 5 horse-power to heat it. The cars are double doored at each end, loose windows, and they run about 20 to 25 miles an hour in the suburbs. There is an immense amount of leakage of cold air into such a car as such a speed, with the constant closing and opening of doors, and yet those cars are comfortably warm and have been all fall and winter. Now that is a very decided step forward in the last three or four years. What I am looking forward to is whether they can get the cost down. I do not believe that it is impossible, for I have seen so many wonderful things worked out in the last ten years. I look into a thing of this kind, because if it is a better thing than I have now, and if there is money in it, I want to go into it.

Mr. Baldwin:—Another point where electricity might be used: Where you have a resistance coil you might use the power of the dynamo in a compressor. It takes a certain amount of force to compress air and heat is the result. About one-half of all the force necessary goes to heat. So you might take power from the dynamo and put it into a compressor and get nearly one-half the power that went into the dynamo in the heat of compressing air. I think that method is feasible to some extent, and you might get one-half of all the energy you originally put into the dynamo.

XI—TOPIC NO. 7

Necessity of automatic air and water valves on steam systems.

Mr. Jellett :—There are two or three sides to this question. I have put in a number of systems of steam heating that do not use any air valves at all. I have also put in other systems of heating where they are an actual necessity. Where I use an overhead system of steam heating in an office building or hotel I never use an air valve. Our western friends call this system a three-pipe system. I never call it by any such name, because I do not think it is properly applied. They try to distinguish it from the ordinary two-pipe system by giving it that name. They say it is solely a Philadelphia institution. I do not know whether that is correct or not. I never investigated it far enough to know, but with an overhead supply system I get rid of two of the great annoyances of a steam heating system. I never yet saw an automatic air valve that was automatic beyond a certain time. It loses its elasticity and sticks, and there is trouble with it, and the trouble is helped along considerably by every fellow handling it. I have frequent complaints from large office buildings that certain radiators do not heat. I find the air valve choked, the radiators air bound. Another building came to me to be fittted. It has some 420 rooms. The specifications called for air valves. The contract was awarded to me. I then went to the architect in charge and said, "If I can put you in a system without the use of air valves, will you accept that and omit them from the specifications?" He said, "Yes, if you can make them all right, I won't make any objections. An air valve is a great nuisance." I then applied to each of the radiators the ordinary feed valve and on the return I put in a swinging check. I supplied steam by one main pipe leading to the attic. This main branched in the attic and supplied the radiators from the side of the descending steam main. A number of my friends laughed at it. We went ahead with it, and drained the end of each vertical feed by inserting a bleed pipe. I did not have to force any steam up through mains. I branched and dropped, and the water of condensation passed out of the base of these vertical pipes. The drains from base of these pipes were connected with a separate system of bleed lines. That is where the reason for calling it the three-pipe system comes in—the system of reliefs in the basement. This relief was brought back to the tanks controlled with a trap, and the returns were also brought back and trapped separately. Directly back of those traps I inserted an air pipe into the return and into the bleed lines. I connected to the

atmosphere through a breathing pipe. I put a gate valve on this. In the morning, when the system is started up, the engineer opens this valve and allows all the air from the system to flow right through. I have one building with 427 radiators. I have other buildings that are worked from the central plant. I am putting in a building that has 48,000 square feet of radiating surface, and I do not propose to put an air valve on it. In general practice I do not use on any such system an air valve. In a gravity system it is a necessity. The pressure is maintained equal on both the supply and returns, and the conditions are different.

Mr. Carpenter :—Where does he place his air vent, I would like to ask?

Mr. Jellett :—They are inserted in the main return pipe directly back of the traps, and those two vent pipes are joined into one and connected into the base of the vapor pipe from the well or base of the summer exhaust, if you have an independent summer exhaust. There is no earthly reason why air cannot be brought out at one point just as well as out at twenty points.

Mr. Carpenter :—That is opened up in the morning at first?

Mr. Jellett :—Yes.

Mr. Carpenter :—And that is closed when the air is sent out to the entire system.

Mr. Jellett :—It is simply a breathing pipe through which the entire system is relieved.

Mr. Carpenter :—In piping this way you use about the same size of mains?

Mr. Jellett :—I use the rule that I gave here as to proportion of mains.

Mr. Barron :—As I understand, this is only applicable to downward distribution. I would like to ask how much of ordinary steam heating reduced pressure apparatus, excluding gravity, is done that way? Is it possible to do it in fifty per cent?

Mr. Jellett :—I think so ; yes. It is possible in any building that has an attic. I have had cases in office buildings where they had practically no attic where I used the upper story because the basement had offices. This piping system has another advantage. Take a very tall building, and the pipes going through the first stories are quite large. Those are the rooms that bring the highest rent. The tenants on the tenth or twelfth stories do not pay so much rent, and they are not so particular about the appearance of the rooms. I have in mind an old building in Philadelphia remodelled into an office building. The pipes are distributed along the ceiling of the seventh story. The Mutual

Life Insurance building in Philadelphia has no attic, but they have a very high cornice on the roof and I run around and back of the cornice. The cornice is built in such a way that there is an inner wall, and between the walls I have my distributing system of mains. The New Philadelphia Bourse, which is being erected now, has an attic over the central and eastern portion on the western end. They are changing their attic and making a restaurant and dining room. Now, the parapet wall is carried up five feet. I asked the architect to build me an inner wall and give me a conduit around the roof of this end of the building, and in this I distributed my pipes. I go up at one point, and I branch in the attic and drop from one point. The building is 460 feet long and about 180 feet wide and nine stories high. The basement is used as an exhibition room for machinery. They rent space and furnish power to exhibit any new machines. It is open for the public. It is modelled on the plan of the Hamburg Bourse. The large bourse hall has a space of 1,400,000 cubic feet. The floor will accommodate, say, 6,000 men. On the trusses of the main room are carried nine stories of the office building, in which there are some 420 separate offices. The building has been designed so that no pipes will show in the bourse hall. The inner walls disappear at the third story of the building. It became a problem of getting your steam through. Again, the basement is used for exhibition purposes, for barber shops, for a sub postoffice and a number of purposes of that character. Now, an overhead system in a building like that fits the case, and in every sense it is equal if not superior to the under system. If I have an attic in a tall building, I will take the overhead system every time. I gather the exhausts in if there are electric light engines and elevator pumps, and I bring all these exhausts into the heating main. The aspirations due to a 16 or 18-inch vertical stack 160 feet high, will show a vacuum on the exhaust from the engine. I have frequently seen in the Drexel building in Philadelphia half an inch of vacuum where ordinarily you would look for pressure. There is a gradual drainage of the entire system to the bleed line. It practically takes no pressure at all, because the air valve is at the other end of the system, inducing the return of the steam.

Mr. Barron :—We have with us to-day Mr. J. Leland Wells, of New York, and I would like to hear from him on this particular subject. It would be very hard, I think, to convince an architect that he should put those heavy mains in the top stories as they do in Chicago, and as they are doing now in Philadelphia.

Mr. Wells :—I do not know that there is anything that I can say. I am rather indisposed on general principles to enter into any discussion whatever, for the reason that something that I say might not agree with the opinions of some gentlemeen who are present.

As to this air valve question, which is the subject of discussion, I would say that in my opinion it is impossible by any means whatever to erect a gravity system of heating apparatus without an automatic air valve, and, furthermore, that an automatic air valve to be of use should be dripped, and those drips should be collected and they should be carried somewhere where they won't smell and where the air will have free exit. In addition to that, these automatic air valves should be so dripped that the excess of circulation on one line does not return the reverse way and close the automatic air valve before the particular radiator on which it is placed has become vented of its air. In an apparatus of the character which I understand Mr. Jellett has constructed, it is quite possible to get along without an air valve, and yet I doubt whether each and every radiator in the building by such a method is entirely free from air. The bleeding of returns in the cellar would from my point of view, be objectionable from the fact that, while it takes out the air, it in addition wastes water. This water is more or less heated, and receives heat units which go to waste. The use of an automatic air valve is, as I said a moment ago, an absolute necessity, in my opinion, on a gravity apparatus. Nor would I go so far as to eliminate them from any apparatus. While no doubt Mr. Jellett has succeessfully accomplished it, my reason for that might perhaps be strange to you, but the fact remains that as contractors for the erection of heating apparatus, in 99 cases out of 100, the apparatus that we construct goes into the hands of very ignorant or at best careless people. The very fact that the air valves are monkeyed with shows that the people, at least, are curious. An air valve should be so regulated by the contractor when he leaves his apparatus that it would not be monkeyed with, particularly if it does not set right. Let him send a man to set it. Let them all be set before he leaves them, first seeing, however, that all of the people who use red lead—some people do not, I believe—but all the people who use any arrangement for making tight joints that the apparatus has been thoroughly cleansed of all that. That, and the use of a good air valve, which can only be operated by a key, I think is a sine qua non to all successful heating apparatus.

Mr. Jellett :—I would say that the water of condensation from

the relief pipe is not wasted any more than the water of condensation from the return. It all goes to the drip tank. It is simply an auxiliary return of the condensation from the distributing system.

Mr. Carpenter :—In this system is it necessary to use anything different from common radiators?

Mr. Jellett :—Not at all. I have used various forms of radiators.

Mr. Carpenter :—You do not use a hot water radiator for that?

Mr. Jellett :—Not at all. The Drexel building has the Joy radiator in. The New York Mutual Life has the Bundy with a divided base. The University of Pennsylvania has the Corry radiator. There is no particular form of radiator, any steam radiator can be used. The buildings I refer to are not experiments. Some have been in constant use for six winters.

Mr. Quay :—I was going to say something in regard to the overhead system, but as that is not the question before us I will say nothing about it.

Mr. Barron:—I hope Mr. Quay will speak on that question now.

The Chairman :—We have very little time to take up another topic. We shall be pleased to hear from Mr. Quay.

Mr. Quay :—I refer to one system that we have in, where we have the mains in the attic ; that is a one-pipe system also. We only have one pipe leading from this main to the return main in the basement. There are about 37,000 square feet of radiation in that building, some 540 radiators, and I am pleased to say that we have never had a complaint. It is a hotel building, isolated and very much exposed. You will scarcely find a building in the country that is exposed more than is this, and it is a frail building, and we have never had a complaint in a year and a half of use of the apparatus in regard to the air valves or the heating of the building or anything about it. We have tested the job very carefully at different times. We have not let the owners know that we were testing it. We have done it for our own satisfaction, and we have gotten a great deal of data. We find that in many cases we have fed the first floor radiators off the bottom of the riser. In other cases, we have fed the first floor radiators off the return main. The return main is suspended from the first floor joists in the basement ceiling, and we have never had any trouble with water or with air valves on this system.

Mr. Barron :—Does Mr. Quay use a combined air and water valve?

Mr. Quay :—Yes, it is combined.

XI—TOPIC NO. 8.

Where a propulsion fan is used for heating and ventilating a theater, is an exhaust or aspiratory fan necessary?

No discussion.

XI—TOPIC NO. 9

What should we accept as the minimum standard of ventilation for various buildings and what is the best means to employ to obtain this result?

No discussion.

XI—TOPIC NO. 10.

Current system of air delivery in simple indirect and fan system plants versus plenum chamber systems.

Mr. Prather:—The subject of the relative efficiency and economy of high velocity "current" systems of air delivery, and slow velocity "plenum" or "reservoir" systems, is one of great importance to the heating and ventilating engineer, especially in laying out plants with fan applications. That it is by no means a settled question is made evident by even a casual study of the many plants coming before us every day; we see complex systems with huge "plenum" or "gathering chambers" or "reservoirs," as they are variously called, here and there, with the branch pipes to flues leading from them like the arms of a "devil fish," and again, we see simple systems with the fan blowing into a main "trunk" or duct, and reducing in size as the various branches lead off to the flues, both arrangements being designed by prominent engineers. It will be observed that I use the word "plenum" somewhat peculiarly and meaning "collecting chamber" or "reservoir."

In the primary and very essential matter of the amount of heated surface exposed to loss by radiation in the conveying ducts or pipes from the source of heat or the heater to the induction flues, the simple high velocity current system, with its heater massed at one central point and the heated air blown at a high velocity through comparatively small ducts to the bases of the flues, has by far the advantage over the low velocity system, with its large ducts and its "collecting chambers" and consequent enoromus amount of heated surfaces exposed and subject to loss by radiation. It is like carrying coals from the fire to a given point; they cool the least with the quickest delivery. But the questions of losses of power by friction of high velocity currents; the noise of these cur-

rents themselves in passing through the pipes, and the obnoxious effects when such currents enter a room, are strongly brought up by the "low velocity" advocate. Regarding the first, that of "friction" by high velocity currents, the word "high" is not used in any extravagant sense, but for velocities of 2,500 feet per minute to 4,000 per minute, or even 5,000 feet per minute, if you will, at maximum point, i. e., at fan or heater outlet. These are certainly high velocities when compared with 500 to 1,500 feet per minute velocities, as are figured in many of the low velocity systems, but for properly designed ducts they are not high, and the element of friction in any systems of ordinary length and properly proportioned areas, with these velocities, is very small.

As to the power required for fan propulsion for obtaining these high velocities over that required for large volumes at the very low velocities, it may be said that it is directly proportional to the volume to be moved and the pressure or velocity of the moving air, and we will agree that there is certainly more power required ; but this item is vastly overbalanced by favorable features in the high velocity system. As to the noise of the currents, I have found that in properly proportioned ducts, with deadening joints at intervals and proper care about elbows and corners, avoidance of projecting laps, rivets, etc., and smooth connecting joints to flues or risers, any noise is easily and permanently overcome and avoided. As to the third point, i. e., obnoxiously high velocities of inflowing air into rooms, it never occurs if necessary care and skill is exercised in designing the area of flues and registers, so that the flues, by enlarged areas readuce the velocity, and the registers, by still larger effective areas, again reduce it to the requisite for entering the rooms, say to from 400 to 500 feet per minute.

I had recently brought to my attention a plant in a building 200 feet by 50 feet, and three stories high, very substantially built of brick and stone, and in which the heating and ventilating was planned to be done by a fan blowing the cold air over the heating coils and thence directly into a plenum chamber running through the center of the basement the full length of building, and ten feet square, with the induction flues rising from it to the various rooms to be supplied. With this arrangement it was impossible to heat the building to over 60 degrees or to change the air more than every 15 minutes. The flue areas were ample and the plenum chamber was very well protected. I advised the introduction of ducts from the heater to the flues, and upon their being completed, and with the same fan and heater as before, and less steam pressure on the heater and lower speed of fan, the entire building is

heated to 72 degrees in the same weather as before, and the air changed every eight to ten minutes easily. I have noted many such instances.

The bane of "current systems" in the past has been improperly designed ducts, with sharp corners and rough surfaces, absence of proper arrangements in design to prevent conveyance of noise to rooms, and to secure proper reductions in velocities of air before it flows into the rooms. In first cost, simplicity, and ease of handling, the "high velocity" system has decidedly the advantage. As I have already trespassed on the time limit for these remarks, I will close with the statement that I believe for efficiency and economy of operation, both in fuel consumption and simplicity, a system of air delivery with high velocity currents of 2,500 to 5,000 feet per minute in the main ducts, and properly reduced velocities in individual branch ducts to flues and in the flues, and with properly proportioned and designed ducts throughout, is far superior to a low velocity "plenum" chamber system. I regret the limitation of time prevents the further presentation of data and instructive experience on this subject, but I hope in a possible future paper to cover it.

XI—TOPIC NO. 11.

The consulting engineer and a common specification versus "Free for all" competition for contracts for heating and ventilating plants.

No discussion.

XI—TOPIC NO. 12.

Value of standing committees of the society on tests and standards.

Mr. Quay :—I should think it would be a matter of importance to have standing committees, especially on standards. We find that often a dispute will arise in regard to what is a proper standard of heating and ventilation, and I think if there was a standing committee on that subject that the opinion of that committee, as representing this society, would have a good deal of weight in settling those questions. One point I have in mind where an architect specified a certain sized heater for a fan system. We maintained that he had about twice as much surface in the heater as was necessary, and that he gained no advantage by having this extra amount. He claimed, from reading certain books and certain catalogues, that he was right and he did not want to yield. Of course we gave our reason for our opinion, but I think that if we

had some standard and had some authority from a society of this kind, it would have great weight in settling such questions, and numerous questions come up in that same line.

Major Light :—In connection with tests, going back a good many years, as well as more recently, and the varying conditions accompanying tests, which I do not wish to refer to by particulars, I think it is highly important that there should be a standing committee of qualified men. I think as soon as this society can adopt standard ideas and have tests the better and the higher it will rank among the intelligent and scientific bodies of the country.

Mr. Barron :—The value of all engineering societies, I think, depends on their tests. The only work of the English Civil Engineers and Mechanical Engineers by which we know them is their tests of materials. Our tests would be entirely in relation to heating. We can make tests, and if we had a good committee I think it would be very valuable. I think that is really the great work of the society, the work it should do for the world.

Major Light :—I wish in a brief way to refer to the value of such tests, for 23 or 24 years ago, when I needed information, instead of going through the experimental conditions myself, which at that time involved a great outlay of time as well as money (there were no such organizations as this, and nearly all tests were made for individual interests), I went down to the Franklin Institute in Philadelphia, and went there at different succeeding dates, and followed up their tests very thoroughly. I wish to say at this late day that that was worth more to me than all ther means I could command in helping me to establish my busi. ss practically and forming definite conclusions as to the merits of apparatus and construction.

XI—TOPIC NO. 13.

What is the proper proportion for cold air inlets to hot air furnaces.

Mr. W. B. Wilkinson :—I was asked to present three or four or five suggestions to the meeting as to some practical points that were sometimes found in the experience of persons who were using hot air furnaces very largely, and the difficulties encountered. The statement was made to me that possibly in this meeting of heating and ventilating engineers there might be some who were more particularly in the line of hot air work than other work, and in that case that some practical suggestions for that purpose might be of benefit. As to discussing this point I do not know that it is neces-

sary to take up the time unless there should be some real reason for it and some persons present who would be interested in it. My own experience in hot air heating has been quite extensive, although I started in on steam and hot water work and worked up from that to heating by hot air, and back from that to steam and hot water work.

As to the matter of data in conection with a subject of this kind, I hardly think that it is worth while to undertake to lay down any general plan in reference to this matter. I remember that nearly 20 years ago when I went into the heating business directly with my father, who had been in the business some 20 years before, he gave me certain data to go by in connection with hot air work and also in connection with steam and hot water work, and the first opportunity I had to prepare a plan for work was to take a steam system that was put in and was a failure and make a success of it. I found that I would have to work out my own salvation and go it alone, as it were. I think this is the same difficulty that occurs to most men who come in contact with that line of heating. The proper proportions are the proper things to bring to our minds always in connection with any line of heating. We all find it is so in steam work and hot water work and in the plenum system. In relation to the proper proportions for this particular purpose, I think that it would be well for those who have had some experience to simply state what that experience is. I could say in brief that my experience has been that these proportions depend very largely upon the location of the building and upon the location of the furnace in the building or the heating apparatus. I think that this topic could be just as properly extended to the use and proportion of cold air inlets for indirect hot water heating. The difficulty which arises in the minds of a good many people is how many square inches of inlet shall we supply in order to produce certain results with a certain number of square inches of outlet? When it is applied to hot air furnaces it is also applied to indirect heating to a great extent, only in a different form. I think, Mr. President, that possibly it is not well to take up very much time in the discussion of this topic in this way this afternoon, as there are so many other topics below here that I myself would like to hear discussed, as well as others.

XI—TOPIC NO. 14.

Efficiency of extended surface in steam and water radiators.

No discussion.

XI—TOPIC NO. 15.

The merits, if any, of vertical over horizontal circulation in hot water heaters.

Mr. Barron :—I do not think there is much to say on that. I never met a man yet who could claim that a horizontal circulation was as good as a vertical one. My position is this, that the vertical circulation is decidedly the best for hot water heaters. I would like to ask if the propounder of that question is here, or if it is known who propounded the question.

The Chairman :—He is not here. He is in Chicago. We will pass on to No. 16.

XI—TOPIC NO 16

Joints in sectional steam and hot water heaters, considering them as we find them in ordinary construction, such as gasket joints, screw joints, and push nipple joints.

Mr. Barron :—I do not think we ought to pass this without saying something. I have had experience with screw joints and gasket joints, and with joints where the gaskets were not faced, and it was a very sad experience several times. If a gasket joint is faced it is all right. If they are rough and not faced, as they sometimes have been in the past, they are very poor things. The push nipple joint is a very good thing. I should think it was just as good as a screw joint, and that both are a little superior to the gasket joint except that the gasket joint is very much more easily taken apart. I do not do much with sectional hot water heaters and have had little experience with them.

Mr. Quay :—I have had a hot water heater in my house for the last six months that has a push nipple connection, a push nipple joint, and I am very much pleased with that kind of joint in either hot water or steam sectional heaters. We have never had a leak and we have had one or two of the joints unbolted, and there is no leak there where the work is properly gotten out and the push nipple properly arranged. I think it is a very good joint for this purpose.

Mr. Wilson :—I think that the matter of joints is largely due to the construction of the boiler. There is no question about it that the gasket joints on some classes of work would not be nearly as efficient as they would on others, and while there is quite a tendency on the part of manufacturers to appreciate gasket joints, we all must admit that they are not conducive to long life with-

out repairs. But irrespective of that, as Mr. Barron has already mentioned, there is a matter that makes them desirable in some instances, which is that they can be taken apart and put together readily. I have had experience with these several types and have heard the consensus of opinion of a great many that it was not as good nor near as lasting. But practical experience has shown me that they have pretty good life if they are set properly on faced joints.

Mr. Barron :—I would like to ask Mr. Wilson what his experience has been in regard to packing, because we have used all kinds of packing. I would like to ask what his experience has been with asbestos, the semi-paper packings, and the semi-metallic packings.

Mr. Wilson :—I have had more experience, I must confess, with the rubber packing ; that is, the prepared packing cut with dies made to fit on to a faced joint. I know of the experience of others with the manilla paper joint, of its being very efficient under certain circumstances, being adjusted properly. Just like a great many other things, if care is not taken with them, they are liable to be inefficient. But I know that good results have been obtained from both methods that he speaks of.

Mr. Cobb :—For almost 15 years my personal experience has been exclusively confined to residence heating where a sectional cast iron boiler has come into use almost exclusively, both steam and hot water, and during that time I think I have tried to find out which is best, if there is any best. I have used an asbestos gasket. I have put in the screw nipple joints. I have used the push nipple, and from my standpoint of reasoning I can see no difference in desirability or efficiency in the joint if it is well made. I have had cases with the asbestos gasket where it proved very unsatisfactory, but from careful examination and investigation I invariably attributed it—I think I had good reasons for doing so—to the desire on the part of the manufacturers of the apparatus to cheapen the thing by using a poor gasket, or cheapen the thing in the machine department by not perfectly smoothing the joints off. Any of the joints I regard as perfectly desirable and perfectly satisfactory if properly made.

XI—TOPIC NO. 17.

The advantage possessed by metal over wooden cold air conduits.

Mr. Barron :—I do not think that any one of the present day claims that a wooden duct is equal to metal. In fact they are

generally made, I believe, of galvanized iron. I think very few make them of wood, particularly in connection with steam or hot water.

XI—TOPIC NO. 18.

Wrought iron pipe compared with steel pipe.

Mr. Quay:—I do not care to say anything in regard to the quality of steel as a material to be used in making pipes, nor as to the effect of the gases and chemicals on steel or wrought iron. However, these are questions that I think should be taken up by the engineers from the technical standpoint. But I would speak merely of the comparison of wrought iron and steel pipe as we find it. We do not need to say much about wrought iron pipe, because we have tried that for a number of years and know what it is. We find a good deal of objection to steel pipe as we get it in the market. I believe that steel pipe can be made which could probably be as easily handled, as easily cut, and all that sort of thing as wrought iron, but we do not find it in the market at present. We find often that the pipe is much harder on one side or on the other.

In cutting a thread, the thread is cut deeper on one side or the other, and on account of the pipe not being properly annealed or tempered we find it very hard on the dies, and it requires a good deal more labor to cut it. We also find in some cases that the pipe is thinner than we order. The manufacturers, on account of steel having a greater tensile strength, have considered it does not need to be as heavy as the standard wrought iron pipe. We find the inside diameter of the pipe is a little larger than is called for. Two inches, for instance, would be $2\frac{1}{8}$, and in getting the standard thread the pipe is so nearly cut away that we do not think there is sufficient tensile strength. While there may be strength enough at present, after the pipe begins to rust and is affected in that way, we doubt whether the threads will be of thickness enough to give proper strength. We also find another thing, that the manufacturers are making butt-weld pipe above $1\frac{1}{4}$-inch; frequently it is two inches and in some cases larger, and in cutting this pipe, partially on account of the weld and partially on account of the pipe not being properly tempered and annealed, being so hard that the pipe is split, we find in a number of cases, in cutting the pipe with an ordinary die, that the pipe is split. It seems to me that something ought to be done to remedy this, for the reason that the majority of pipe you get on the market to-day is steel pipe. You have to pay more for wrought iron

pipe. You have to be very particular in specifying pipe if you want wrought iron. You also have to be very particular in specifying that it is lap weld above 1¼-inch.

Major Light :—In executing a contract this last fast fall I made an order on a western house for a quantity of pipe. In filling the order they found it necessary to send us some steel pipe, and we experienced the same difficulty as that mentioned by the gentleman who just spoke as to the thinness of it, and found when the threads were properly cut that there was not sufficient thickness and strength, and it caused us trouble afterward in connection with our contract.

Mr. Barron :—I hesitate a little about talking on this subject, because I have written about the subject and talked about it. It is not generally known how much steam fitters have talked over it and discussed it. It is a singular thing that all the pipe in the market to-day is steel pipe except that made by two concerns. Our men do not want to use steel pipe. We cut all our work by hand and we find that it does not pay at all to use steel pipe, and yet the very manufacturers from whom we get our wrought iron pipe do not make pipe above six inches, and the pipe that they use for their customers is steel pipe (all the large pipe), and they use that on the large pipe, and so far as their experience goes it has no more wear and tear on their dies and on their machines. Steel pipe to-day is supplanting wrought iron pipe rapidly, and all above six inches, I think, is steel. The singular thing about that is that above six inches it is perfectly satisfactory. The very man who is selling wrought iron pipe up to six inches, in his own machines and for his own customers buys steel pipe and uses it. It is a singular thing that they cannot make steel pipe right. One gentleman told me yesterday that the use of steel pipe made their labor cost twenty per cent additional. I am fully convinced that it amounts to all of that, as there is so much dissatisfaction on the part of the men in using steel pipe and so much satisfaction in using wrought iron pipe, which is easy on the men and on the tools. There is five points difference in the discount between steel and wrought iron pipe.

Mr. Wilkinson :—I had a brief experience in the use of steel pipe some few weeks ago in some work we had under contract in Pittsburg, Pa. I had occasion to send one of my own men over there to do his work on the job and to take his tools there. When he got there and found that steel pipe had been ordered for the job he undertoook to do the work and he found a great variety of thickness in the pipe. Some of the pipe would cut all the way through the

thread. Even the small pipe would sometimes split. He wrote me asking what he should do about it. He said he was spoiling all his tools and that it would take him three or four or perhaps five days more to do this work if this pipe was used. I telegraphed him immediately that he had better send the pipe back where it had come from and buy wrought iron pipe if he could possibly get any in Pittsburg. He said he could get it but it would cost him more. Now the people in Pittsburg must have better tools or spend more time and labor. But we succeded in getting wrought pipe. All the steel pipe put in had to be taken out after the work was tested and we had to substitute wrought pipe. I do not want any more experience with steel pipe. When the tools came back it cost considerable time to put them in order. That was a hot water system.

Mr. Carpenter :—Have any of the members had any experience with steel pipe and wrought iron where they have electric currents in the ground ; that is, for returns? I have had in the past year quite a good deal of trouble from the electric current eating out the pipe. We have been using entirely wrought iron pipe. I was wondering whether it made any difference.

Mr. Barron :—I cannot answer Mr. Carpenter's question, but I could make a suggestion that where the difficulty has occurred he could use cast iron pipe to screw. That has been done by one of our engineers in brewery work. Ordinarily wrought iron pipe put underground does not rot out. This gentleman used cast iron pipe screwed the same as ordinary pipe ; had it cast thick, of course, with screw threads and screw couplings, and for brewery work that gave perfect satisfaction.

Mr. Cobb :—I want to voice my experience with steel pipe. My experiences have been precisely in accordance with the general sentiment expressed. It seems to be almost impossible to cut a thread on both ends of a nipple without splitting the pipe. It is practically impossible it seems on some sizes and in some lots. A good many weeks ago I positively declined to use it and specified on all my orders wrought iron pipe. But it comes steel pipe just the same.

Mr. Quay :—I suppose there is not time to-night to discuss the question, but I think it would be well to take up this matter of the durability of steel as compared with wrought iron and the effect that the different gases and chemicals have on the different pipes. We find sometimes that engineers specify steel pipe. I find one or two cases where they specify that it must be steel pipe. I think that from an engineering standpoint we should at some time take up

this question, and there should be tests made, and the subject should be investigated and written about.

The Chairman :—It might possibly come under the head of our testing committee.

Mr. Barron:—We are placed in a peculiar position. We do not want to bar progress and condemn steel pipe, because we are all in favor of steel as against iron. It is simply a qustion of progress and pains. If this society and the Master Steam Fitters' Association both put down their feet, I think the manufacturers, or some of them, would produce the pipe we want. What we want is soft steel pipe.

XI—TOPIC NO. 19.

Compensation for plans and specifications.

No discussion.

XI—TOPIC NO. 20.

Are mushroom registers under auditorium seats advisable, or are all flow entrances for warm air objectionable?

Mr. Barron :—I proposed that topic, and it came to my mind through having a set of plans sent to me for a new theater. The specification was a plenum system of heating and ventilation. It was a splendid system. I was simply astounded that the owner would pay for such a fine and elaborate system of heating and ventilation. What struck me was the tremendous number of floor registers distributed through the building. That building would be thoroughly ventilated. There were forcing fans and exhaust fans to make a very complete ventilating and heating apparatus. I thought it was a great mistake to have mushroom registers under the seats. To my mind that took in a lot of dirt and dust from the floor and seats. I think all floor entrances are in the same category. There is always dust and dirt on floors and when air is flowing on there it is blown into your breathing apparatus. I think all air should come in above the dust line so that no manipulation of the apparatus can possibly stir the dust up and get it in the breathing line. I believe that a fairly good ventilation will reach that point before a great while. I was talking this over with an engineer who does a great deal of ventilating, and he said that he approved very much of the mushroom registers. He said, "You know in good theaters and buildings of that kind people do not come in with dirty feet and the carpets do not get dirty." I thought afterwards that these very people walk in the dust, and these very theaters he had reference to I examined a little and I found them

very dusty. I am sure that the air coming through these mushroom registers cannot help throwing up some dust and sending it into the breathing line.

Mr. Quay :—I would ask Mr. Barron where the exhaust registers were in this case?

Mr. Barron :—If I remember correctly there were flues in the side walls. Under the gallery there was one register at the exhaust flues and one at the floor line. There was also, I believe, as in an ordinary theater, a direct exhaust outward. These flues had independent discharges of air. It was a very complex apparatus. A man could not design it more elaborately.

Mr. Quay :—It would seem to me that they were bringing the air in right where they expect to find the foulest air in the building. I should think that was contrary to the experience of the best engineers.

Mr. Harding :—I think as long ago as when Dr. Reid wrote his book touching the ventilation of the Houses of Parliament, the method of introducing the air was through perforations made throughout the entire surface of the floor, and that was covered by a coarse matting. That was given up entirely for the same reason that I think the mushroom registers will be given up—the air is brought to the point of contamination and contaminated and circulated.

XI—TOPIC NO. 21.

In designing a hot water system shall we assume a cooling in the radiators of 15, 20, 25, or 30 degrees?

Mr. Wilson :—That is a question which I think is very indefinite. It depends entirely upon the length of the mains and numerous other conditions.

Major Light :—Mr. Chairman, I think that is governed entirely by the amount of protection there is to the system, the piping and connections considered. At least that has been my experience. I have found it possible to protect my pipe so thoroughly that the condensation would come back from the coils at such a high temperature that steam which was given off in the receiving tank had to be liberated, and through a tell-tale at the foot of the work, steam would flow at the foot of the pipe. Under such conditions the cooling condition is not to be so large a one, while if it is not properly protected it would be much larger.

The Chairman :—That refers to steam. This question is on hot water.

Major Light:—Yes; but I would draw the parallel between the two. I made the same tests on hot water.

Mr. Quay:—They do not state whether this is an open tank or closed tank system of heating. I wish we had time to discuss these questions.

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